

**'Access to Radiotherapy for Cancer treatment (ARC) Project':
Guidance for low and middle-income countries establishing safe and
sustainable radiotherapy services**

By

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the Degree of Doctor of Philosophy

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Certificate of Original Authorship

I, Andrew Donkor, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy degree, in the Faculty of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution.

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Thesis Format

This is a compilation thesis comprising of title, list of publications, table of contents, list of tables, list of figures, list of appendices, abstract, abbreviations, glossary of terms, seven chapters and references.

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Abstract

Introduction: Efforts to improve access to cancer care, including radiotherapy services in low and middle-income countries (LMICs) is challenging. Many radiotherapy initiatives in LMICs have failed to fully deliver on their promise because of multi-faceted barriers at the systems, organisational and patient levels, leading to significant wastage of scarce resources. Greater guidance on how to assess and build LMICs' readiness for establishing sustainable radiotherapy services is needed to improve cancer care outcomes in LMICs.

Aim: The 'Access to Radiotherapy for Cancer treatment (ARC) Project' aimed to provide practical guidance to LMICs on establishing safe and sustainable radiotherapy services.

Methods: The mixed qualitative methods ARC Project involved a: systematic review; and two-part qualitative study. The systematic review synthesised strategies adopted by LMICs to improve access to cancer treatment and palliative care. Semi-structured interviews undertaken with global radiotherapy experts explored perceived facilitators and barriers to establishing sustainable radiotherapy services in LMICs. The mid-point meta-inference of the systematic review and semi-structured interview data generated a draft list of requirements, which was circulated to global experts during the second part-of the qualitative study. The final meta-inference was undertaken following the completion of the three studies.

Findings: The systematic review identified that comparatively few studies have focused specifically on improving radiotherapy in LMICs, with no research evaluating effectiveness. The semi-structured interviews identified three key facilitators to establishing sustainable radiotherapy services in LMICs, namely: committing to a vision of improving cancer care; making it happen and sustaining a safe service; and leveraging off radiotherapy to strengthen integrated cancer care. The mid-point meta-inference generated 42 potential requirements, which were organised into four readiness domains: commitment (n=13); cooperation (n=7); capacity (n=17); and catalyst (n=5). The participant validation confirmed 37 of the generated requirements as relevant for inclusion in a radiotherapy service development readiness self-assessment guide for use by LMICs.

The end-point meta-inference of the ARC Project's integrated data presented the '**RE**adiness **SE**lf-**A**ssessment (RESEA) Guide', with 120 questions that may help LMICs at macro and meso level to determine and create action plans to improve their readiness to establish radiotherapy services.

Conclusions: The ARC Project has identified a complex combination of facilitators and barriers that influence the establishment of sustainable radiotherapy services in LMICs. It has developed a RESEA Guide to provide support for LMICs seeking to establish sustainable radiotherapy services. Further work is needed to evaluate the acceptability and feasibility of the RESEA Guide and inform further refinements.

Abbreviations

ARC Project	Access to Radiotherapy for Cancer treatment Project
COREQ	Consolidated criteria for Reporting Qualitative research
GLOBOCAN	Global Cancer
HICs	High-Income Countries
IAEA	International Atomic Energy Agency
ICTS	Information and Communication Technologies
LMICs	Low and Middle-Income Countries
NCDs	Non-Communicable Diseases
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
REASEA Guide	REadiness SElf-Assessment Guide
UICC	Union for International Cancer Control
WHO	World Health Organisation

Glossary of Terms

Access	Access is a complex concept and at least five aspects require consideration: • accessibility is whether the services are effectively available for utilization; • affordability is about a system for financing health services, so people do not suffer financial hardship when using them; • appropriateness indicates services available ought to be relevant to the different parts of a population in terms of their health needs and material and cultural settings so as to ensure that the population would have access to positive health outcomes; • adequacy is whether there is an adequate and continued supply of available services; and • availability is whether services are available in the first place (Souliotis, Hasardzhiev & Agapidaki 2016).
Barriers	The obstacles that impede the effective implementation, sustainability and/or scale-up of cancer treatment and palliative care strategies.
Cancer	It is an abnormal cell divide in an uncontrolled biological mechanism and has the ability to spread into or invade other tissues (Cooper & Hausman 2000).
Capacity	The LMIC's ability to translate commitment and cooperation to achieve sustainable results through effective and efficient management of the implementation process, a prepared workforce, maintenance, governance and information technology
Catalyst	The potential for LMICs to leverage from a radiotherapy service to develop an integrated cancer care service
Cooperation	The effective involvement of relevant international, national and local stakeholders in the planning, commissioning and operationalisation of a new radiotherapy service
Commitment	The LMIC's willingness to put in place the necessary political, policy, funding and regulatory requirements to enable a radiotherapy service to be established
Confirm	When a current study reinforces the findings of the previous study
Enhance	When a current study further improve the findings of the previous study
Facilitators	Enabling factors that support effective implementation, sustainability and/or scale-up of cancer treatment and palliative care strategies.
Radiotherapy	The use of high energy rays in its different forms (X-rays, Gamma rays or particles) to cure or control cancer. Radiotherapy can either be external beam or brachytherapy. External beam radiotherapy is a non-invasive method of delivering targeted radiation to a tumour using equipment such as linear accelerator. Brachytherapy, which is also known as internal radiotherapy, involves implanting radioactive directly into or next to the tumour (Deeley 2013).
Readiness	The preparedness, willingness and response to develop, implement, sustain and/or scale-up improvement strategy (or change) (Holt et al. 2007; Weiner 2009).
Implementation	It is the process that puts strategies, plans and policies into action or effect to achieve desired goals (Saunders 2015).

Requirement	It is any task, decision, procedure or necessary condition that supports the LMIC goal to establish a sustainable radiotherapy service. A requirement ideally needs to be satisfied by the LMIC for establishment a local radiotherapy service.
Stakeholder	Any individual, group or organisation that has an interest in developing, implementing and/or sustaining radiotherapy in low- and middle-income countries. They may be directly or indirectly involved with cancer radiotherapy (Bourne 2016; Fontaine, Haarman & Schmid 2006).
Sustainability	The ability or effort to maintain an improvement strategy (or change) that suits current needs without compromising or jeopardising the needs of future generations (Emas 2015).

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Chapter One: Introduction

1.1 Overview

Globally the burden of cancer is increasing, and this growth is most apparent in low and middle-income countries (LMICs). Providing best evidence-based cancer care in LMICs is challenging but is urgently required. This Chapter explores the global epidemiology of cancer, the increasing burden of cancer in LMICs, cancer care continuum and sets the policy context for improving cancer care in LMICs.

1.2 Global epidemiology of cancer

The word 'cancer' strikes terror more than any other term in medicine (Huang 2014). Cancer is a disease that affects people living in both high-income countries (HICs) and LMICs (Harris 2016). Cancer is a global threat in terms of the possible loss of life, impoverishment of families and communities and damage to a country's economy (Knaul et al. 2011). Cancer not only causes significant morbidity, but is also responsible for the deaths of millions of people annually. The growing burden of cancer morbidity and mortality occurs despite global medical and public health efforts (Baskar et al. 2012; Bray et al. 2018).

The International Agency for Research on Cancer estimates that, in 2018, there were 18.1 million new cancer cases and 9.6 million cancer deaths (Bray et al. 2018). Globally, these estimates reflect increases of 21.5% in new cancer cases and 17.1% in cancer deaths over the five year period between 2013 and 2018 (Bray et al. 2018; Global Burden of Disease Cancer Collaboration et al. 2015). By 2040, the global burden of cancer is projected to reach 29.5 million new cases and to cause 16.5 million cancer deaths (Torre et al. 2015; Torre et al. 2017).

Globally, lung cancer continues to be the most diagnosed cancer (2.1 million) and the most lethal, causing 1.8 million cancer deaths in 2018 (Bray et al. 2018). Colo-rectal (0.86 million), stomach (0.77 million), liver (0.77 million) and breast (0.67 million) cancers caused an additional 32% of the total global cancer deaths in 2018 (Bray et al. 2018). In the next 10 to 20 years, it is expected that cancer will become the leading cause of death in every world region regardless of the level of human or economic development (Dagenais et al. 2019). Deaths from cancer now constitute approximately 16.8% of the 57 million annual global population deaths (Bray et al. 2018).

1.3 Increasing burden of cancer in LMICs

Unfortunately, LMICs face a double burden of disease, due to the epidemics of communicable and non-communicable diseases (NCDs) (Global Burden of Disease Study 2016 Causes of Death Collaborators 2017). The double burden of disease is a consequence of the improving

economic standards of most LMICs. The improved economic standards have translated into increased life expectancy (Farmer et al. 2010).

New cases of cancer and deaths from cancer continue to increase in LMICs. During the period 2012-18, the annual number of new cancer cases increased by 23.8% (from 8 million to 9.9 million) and the annual number of cancer deaths increased by 26.4% (from 5.3 million to 6.7 million) in LMICs (Bray et al. 2018; Bray et al. 2012). These increases have been driven by factors, including: population growth and aging, unavailability of preventive, screening and treatment services, increasing prevalence of risk factors associated with socio-economic development and westernisation, such as smoking, unhealthy diet and physical inactivity (Farmer et al. 2010; Shah et al. 2019).

Cancers of the lung, breast, colon and rectum that are associated with the above mentioned risk factors are now on the rise in LMICs (Bray et al. 2018). Also, cancers of the cervix-uteri, liver and stomach that are associated with infections, such as human papillomavirus, hepatitis B and C viruses and *Helicobacter pylori* are more common in LMICs (Bray et al. 2018). The burden of cancer in LMICs may be underestimated because most of these countries do not have cancer registries for accurate and reliable data collection and reporting (Siddiqui & Zafar 2018).

1.4 Caring for patients across the cancer care continuum

Effective organisation of healthcare services play a critical role in the care of people across the cancer care continuum, from prevention, screening, diagnosis, treatment, through to survivorship and palliative and end of life. Healthcare professionals caring for cancer patients across the continuum ought to have appropriate competencies, equipment and tools to perform their roles. Coordination, continuity and communication among healthcare providers are essential to enable safe transitional care (Nekhlyudov 2019). In most LMICs, healthcare organisations are not designed to address chronic conditions, such as cancer. Policy-makers in these countries have rarely been able to create a planned programme for the population across the continuum of cancer care, which affects cancer patients' navigation experiences (Dalton et al. 2019). Most cancers are preventable and treatable; but most LMICs are unable to seize opportunities to inform citizens about health promotion, cancer prevention strategies and invest wisely in cancer treatment and care. Unfortunately, despite the growing burden of cancer, most LMICs lack the healthcare workforce with the required expertise, tools and technique to appropriately diagnose and treat cancer (Cazap et al. 2016).

1.4.1 Cancer prevention

Cancer prevention include activities that help to reduce the incidence and burden of cancer. Cancer prevention is categorised into three types, namely: primary; secondary; and tertiary prevention activities (Goel & Overholser 2019). Primary prevention consists of activities such as genetic counselling and testing, education on modifiable behavioural risk factors and

vaccinations that help to reduce the risk of cancer ever developing. Secondary prevention involves activities that detect and/or treat cancer at precancerous stages or before clinical symptoms become noticeable. Cancer screening, such as population-based mammography screening programme is an example of secondary prevention effort. On the other hand, tertiary prevention are activities that focus on reducing the complications or recurrence of cancer after treatment. Tertiary prevention approaches include counselling to improving quality of life; therapies to relieve symptoms; screening for secondary cancers; and surveillance for late effects of cancer treatment (Goel & Overholser 2019).

1.4.2 Cancer screening

Cancer screening is an effort to reduce suffering and death (Goel & Lin 2019). Cancer screening is a process of testing asymptomatic individuals with the aim of initiating diagnosis and treatment (Brawley 2019). Three core requirements for successful screening are: a cancer that can be identified in a localised state before it spreads; a test that finds localised disease with some reliability; and a treatment that is effective against the localised cancer (Brawley 2019). Basic criteria for screening programmes include: responding to a recognised need; clear screening objectives; well defined target population; available scientific evidence supporting the programme effectiveness; integrated education, testing, clinical services and programme management; quality assurance to minimise potential harm; and promote equity and access to screening for the entire target population (Andermann et al. 2008).

The World Health Organisation (WHO) recommends screening for breast, cervical, colon and rectum cancer (WHO 2007a). Faecal occult blood testing for colon and rectum cancer, as well as lung, breast and prostate cancer screening aim to diagnose cancer at an earlier and treatable stage. Such screening programmes do not prevent the cancer; but they increase recorded incidence and improve survival rates (Wardle & Marlow 2019). Public awareness that cancer screening exists is a critical first step to participation. Awareness of cancer screening is improved by written invitation for testing in countries with established cancer screening programmes (Wardle & Marlow 2019).

1.4.3 Cancer diagnosis

Diagnostic services such as imaging procedures (computed tomography scan, magnetic resonance imaging and ultrasound scan), laboratory and pathology services seek to provide timely clinical and histopathological confirmation of cancer in suspected cases (WHO 2007b). Diagnostic services are necessary for cancer staging, treatment monitoring and evaluation as well as follow-up investigations (Peairs 2019; WHO 2007b). Cancer staging helps the multidisciplinary oncology team to plan cancer patient's treatment and prognosis. The optimal diagnostic and staging of cancer requires a multidisciplinary collaboration among the primary health care service, oncology, radiology and laboratory services (WHO 2007b).

1.4.4 Cancer treatment

The aim of cancer treatment services is to cure the cancer or prolong life while optimising quality of life. Cancer treatment is complex and involves the use of surgery, radiotherapy and systemic anti-cancer therapies (WHO 2007b). These treatments may be warranted in various combinations depending on the type and stage of cancer. Most cancer treatments require diagnostic and therapeutic cancer services such as surgery, radiotherapy and systemic anti-cancer therapies, with well-equipped and skilled clinicians. Unfortunately, in many LMICs meeting these demands is not always possible due to high costs and lack of infrastructure (Haier, Sleeman & Schäfers 2019; Sirohi et al. 2018). For example, oncology surgeons can only provide safe and high quality cancer care once they have successfully completed a lengthy training program, often outside of the LMIC, have access to the appropriate infrastructure and are supported by a competent inter-professional cancer care team (WHO Sullivan et al. 2015; 2007b).

Radiotherapy services are often provided in regional, national or tertiary cancer centres where the suitable infrastructure and professional expertise are available. Radiotherapy centres require qualified radiation oncologists, radiation therapists, medical physicists, maintenance engineers and other supporting staff (Atun et al. 2015). Quality assurance devices, such as treatment planning system, dosimetry tools, immobilisation devices, imaging devices and shielding devices are essential to deliver radiotherapy services (WHO 2007b).

Systemic anti-cancer therapies include pharmaceutical agent(s) administered with the intent to change the outcome of the cancer and/or provide symptom relief. Systemic anti-cancer therapies include a range of therapeutic agents, such as antineoplastic drugs (chemotherapy and targeted therapies), immunotherapy agents and endocrine (hormonal) therapy agents. Specialised professionals, such as medical oncologists, haematologists, pharmacists and nurses are required to deliver systemic anti-cancer therapies. Availability of a country-wide protocol, with prioritised cancers and a list of systemic anti-cancer therapies and other essential medicines is critical to provide a standardised cancer care (WHO 2007b).

1.4.5 Survivorship

A cancer survivor is any individual who has been diagnosed with cancer, living with, through and beyond cancer from the time of diagnosis (Berry et al. 2019). In HICs, more individuals are surviving cancer and living longer because of medical advances in early detection, diagnosis, treatment and supportive care strategies. This has led to the emergence of cancer as a chronic illness (Phillips & Currow 2010). Thus, cancer survivors may require specialised care, support and long-term follow-up care for years to cope with physical effects of cancer and its treatment, which may have the potential to affect the psychosocial, economic, functional capacity and cognitive function (Miller et al. 2019).

In HICs, the need for survivorship care has increasingly been emphasised over recent years to improve the health and wellbeing of individuals living with and beyond cancer (Feuerstein & Nekhlyudov 2018). The transition from active cancer treatment to post-treatment care and recovery has been recognised as critical to cancer patients and their family members' wellbeing. Regardless of the country, cancer survivors require evidence-based information tailored to their special needs and circumstances (Lister & Dougherty 2019).

However, most healthcare professionals in LMICs do not have access to up-to-date evidence-based guidelines or available guidelines are not applicable to the local setting and clinicians have had little or no formal training in the follow-up care of cancer survivors (Ismaila et al. 2018). Therefore, cancer survivors are less empowered and supported to participate in shared decision-making and self-management (Jacobsen & Mollica 2019).

Cancer survivors may encounter physical, psychological, cultural, spiritual and social issues, such as financial and occupational, which makes minimising their burden of disability a priority (Phillips & Currow 2010; Salakari et al. 2015). Hence, supportive care is critical to help cancer survivors manage cancer co-morbidities, treatment related side effects and make informed lifestyle choices to decrease the risk of recurrence (Butow et al. 2012).

In most LMICs, where there is lack of coordinated and integrated cancer care, there is less focus on timely communication between cancer survivors and healthcare providers (Harding, Nair & Ekstrand 2019). Healthcare providers are often ill-equipped to connect with cancer survivors to timely manage some of the enduring side effects of cancer treatment. As a result, cancer survivors often find that no one is paying attention to the treatment side effects they experience and how to navigate the survivorship pathway for better outcomes (Anwar et al. 2018; Chan et al. 2017; Dalton et al. 2019).

1.4.6 Palliative care

WHO defines palliative care as:

an approach that improves the quality of life of patients (adults and children) and their families who are facing problems associated with life-threatening illness. It prevents and relieves suffering through the early identification, correct assessment and treatment of pain and other problems. Palliative care is the prevention and relief of suffering of any kind – physical, psychological, social or spiritual... It promotes dignity, quality of life and adjustment to progressive illnesses, using best available evidence (WHO 2016a, p. 5).

Palliative care is especially important in LMICs because many cancer patients already have advanced disease at the time of presentation and may not receive curative treatment (Hannon et al. 2016). Palliative care is not intended to either hasten or postpone death but instead prioritises quality of life. It emphasises the need for shared decision-making and advanced care

planning to identify and address patients' needs and preferences for care at the end-of-life (WHO 2016a).

The accessibility and availability of palliative care varies by world regions. Greater palliative care integration into healthcare system is advanced in countries with higher human development index and higher gross domestic product (Gwyther & Krakauer 2011; Lynch, Connor & Clark 2013; The Economist Intelligence Unit 2015). Ideally, palliative care should ensure equitable access to essential medicines, competent healthcare professionals and quality interventions to assured safety and cost-effectiveness. However, palliative care is largely ignored in most LMICs because of barriers such as: misinformation about the suitable medical use of opioids; limited awareness and advocacy; lack of investment; and restrictive policies (Knaul et al. 2017).

Many people with cancer will need both primary palliative care and specialist palliative care (Bruera & Hui 2015; Clinton & Meier 2011; Hui & Bruera 2016; Quill & Abernethy 2013). Primary palliative care refers to the care provided to patients by healthcare professionals who are not palliative care specialists. Primary palliative care providers include general practitioners, nurses, community health workers, social care workers, residential aged care workers and volunteers (Hui & Bruera 2016). With the appropriate skill sets, primary palliative care providers can offer basic: management of pain, depression and anxiety; and discussions about prognosis, goals of treatment and suffering (Quill & Abernethy 2013).

Specialist palliative care refers to the care provided by a team of healthcare workers equipped with specialist knowledge and skills to manage complex symptoms experienced by patients with life limiting illness from a variety of settings, including: specialist inpatient consulting services, hospices and community-based specialist services (Quill & Abernethy 2013). In most HICs, providers of specialist palliative care are responsible for training and conducting research in palliative care (Martinez 2011). However, specialist palliative care services remain rare among LMICs and patients with cancer pain is undertreated or not treated at all (Knaul et al. 2017; Worldwide Palliative Care Alliance & WHO 2014).

With infrastructure support, primary palliative care can be provided using limited resources. A notable example is the African Palliative Care Association integration programme, which is creating awareness and training healthcare professionals to deliver primary palliative care services (African Palliative Care Association 2020; Fraser et al. 2017). The African Palliative Care Association (2020) strategy relies on identifying champions of palliative care so that palliative care is incorporated into the health plans of governments and curricula for all medical, nurse and allied health professionals training to ensure palliative care provision becomes sustainable. Another example is the Neighbourhood Network in Palliative Care in Kerala, India, which relies on local community to identify patients in need of help, plan strategies and help them with active support from community health workers and volunteers. The service provided

by Neighbourhood Network in Palliative Care covers a population of more than 15 million (Bollini, Venkateswaran & Sureshkumar 2004; Kumar 2013).

The section above has explored the global epidemiology of cancer, increasing burden of cancer in LMICs and the cancer care continuum. The section below presents the wider global policy context for improving cancer control.

1.5 Global cancer control policy context

Improved policies and financial resources have been recognised as important factors that may facilitate cancer control in LMICs (Prager et al. 2018). Global organisations and agencies, such as WHO, Union for International Cancer Control (UICC), International Atomic Energy Agency (IAEA), International Agency for Research on Cancer, American Cancer Society, National Cancer Institute and National Cancer Research Fund International have been developing and promoting resources that advance cancer control policy, training and education, advocacy, funding and research in LMICs.

1.5.1 Cancer and Sustainable Development Goals

Preventing and treating cancer are sustainable development issues. However, the 2015 Millennium Development Goals, adopted by the 70th United Nations General Assembly have been criticised for ignoring mental health, disabilities and NCDs, including cancer (Besada, Polonenko & Agarwal 2017; Liverman 2018). The Millennium Development Goals overlooked cancer; hence, the limited funding and support to develop initiatives to control cancer in LMICs.

In expanding the Millennium Development Goals, the Sustainable Development Goals integrate a range of areas that were not covered in the Millennium Development Goals, such as health and equity. Therefore, the objective of Goal Three of the Sustainable Development Goals is health for all, which is to: “ensure healthy lives and promote well-being for all at all ages” (United Nations 2017). Goal Three targets cover all major health topics, including: reproductive, maternal, newborn and child health, communicable diseases, NCDs, mental health, universal health coverage, road traffic injuries and health systems strengthening. It is also the first time that the global development agenda have recognise that NCDs impact on all facets of sustainable development (WHO 2016b). Unlike, the Millennium Development Goals, the Sustainable Development Goals bridge governments, private sector and civil society to create innovate strategies to achieve sustainable development in cancer control.

1.5.2 Cancer and universal health coverage

The concept of universal health coverage assists people to achieve an attainable standard of physical and mental health, which is a basic human right (Ghebreyesus 2017; Non-communicable Disease Alliance 2018). Universal health coverage is about ensuring that

everyone, regardless of income, class and race has access to quality essential health services, including cancer prevention, early detection, treatment, rehabilitation and palliation without financial hardship (WHO 2010).

Universal health coverage is an aspiration for countries around the world, including LMICs. Governments and health authorities have been encouraged by the WHO to engage in health reforms to expand and improve health service coverage with the required financial protection (Boerma et al. 2014). Availability of universal health coverage programmes helps to detect and treat diseases earlier. Universal health coverage helps reduce the rate at which individuals seek health care abroad (Cotlear et al. 2015).

Key challenges that limit LMICs implementation of universal health coverage include: poorly developed income and business tax systems; unavailability of resources; ineffective and inequitable use of limited resources; and excessive dependence on direct payments at the point-of-care, which discourages patients from seeking care (WHO 2010).

To move towards universal health coverage, LMICs ought to improve the efficiency of their revenue collection to generate more funds that can be used to build healthcare infrastructure, buy essential medicines and develop and allocate human resources to provide services to the population (Reich et al. 2016). Also, governments ought to design and implement innovative financing strategies that suit their economies (Savedoff et al. 2012). Such innovative financing strategies for domestic fundraising for health include: the tax on foreign exchange transactions; diaspora bonds and solidarity levies on services like mobile phone calls and income tax; taxes on products that are harmful to health, such as tobacco, alcohol, foods high in salt and sugary drinks (WHO 2010).

1.5.3 Cancer prevention and control policy resolutions

Over time, the WHO has recognised the role of global policy resolution to preventing and controlling cancer. It has repeatedly developed and adopted policy resolutions calling for more significant effort in controlling cancer. In 2005, the WHO adopted the cancer prevention and control policy resolution to respond to the high cancer incidence and mortality burden (WHO 2005). The approved resolution required all Member States of the World Health Assembly to commit and strengthen action against cancer by developing and implementing cancer control programmes and build capacity for cancer prevention, early detection, diagnosis, treatment and palliative care (WHO 2005).

Also, during the 70th World Health Assembly, the WHO 2017 cancer prevention and control in the context of an integrated approach resolution was adopted by Member States across all regions, which represents an update to the 2005 WHO cancer resolution (WHO 2005; WHO 2017). The 2017 WHO cancer policy resolution outlines a road map for stakeholders to appreciate the potential for prevention, diagnosis, treatment and palliative care for people living

with cancer (WHO 2017). Recommended actions for Member States include: sustaining leadership and commitment to develop and implement a national cancer control plan with focus on equity and access as part of national responses to NCDs; strengthening collaborations through regional and subregional partnerships to create centres of excellence for the management of cancers; promoting the availability and affordability of quality, safe and effective medicines, vaccines and diagnostics for cancer; fostering partnerships between government and civil society; and improving data to inform decision-making (WHO 2017).

1.5.4 Creating scientific evidence to support better policy decisions

Recent evidence that have been developed and have articulated the detailed burden of cancer in LMICs and how to effectively and affordably respond to this equity and health imperative, include: Global Task Force on Expanded Access to Cancer Care and Control; Lancet Oncology UICC Commission on Global Radiotherapy; Lancet Commission on Global Access to Palliative Care and Pain Relief; and Lancet Oncology Commission on Global Cancer Surgery (Atun et al. 2015; Knaul et al. 2017; Sullivan et al. 2015).

Global Task Force on Expanded Access to Cancer Care and Control

In 2009, the Global Task Force on Expanded Access to Cancer Care and Control in developing countries, herein referred to as Global Task Force on Cancer, was formed by the Harvard Global Equity Initiative, Dana-Farber Cancer Institute, Harvard Medical School and Harvard School of Public Health (Knaul et al. 2011). The Global Task Force on Cancer convened global health and cancer leaders from every world region, which included researchers, clinicians, policy-makers, private sector, patients and family members (Knaul et al. 2011).

The Global Task Force on Cancer is charged to: design, develop and implement initiatives to raise awareness of the impact of cancer on LMICs at the global, regional and national levels; identify appropriate packages of essential cancer care services for LMICs; and promote universal access to treatments for cancer, pain control and palliation through financing and procurement of affordable cancer drugs, vaccines and services. The Global Task Force on Cancer approach is to partner with and support existing initiatives while developing and implementing multi-stakeholder plans to improve access to cancer care and control via health system strengthening that deliver comprehensive health coverage (Knaul et al. 2011). The approach also calls for the development and effective utilisation of existing physical, technological and human resources while sharing the implementation lessons learned (Knaul et al. 2011).

Commission on Global Radiotherapy

In 2013, the UICC board approved the convening of a Global Task Force on Radiotherapy for Cancer Control, herein referred to as the Radiotherapy Task Force, with the mandate to

estimate the: future global burden of cancer and the demand for radiotherapy; facilities, equipment and workforce needed to deliver high-quality radiotherapy services; and estimate the costs and benefits of radiotherapy investment. The Radiotherapy Task Force is an international partnership involving economists, oncologists, physicists, global health authorities and industries (Atun et al. 2015). The Radiotherapy Task Force and together with the resultant Lancet Oncology Commission on Global Radiotherapy, which was launched in 2015 has successfully quantified the investment required to expand access to global radiotherapy services by 2035. The Radiotherapy Task Force finding reveals the economic returns and the lives that will be saved or prolonged by expanding access to radiotherapy services in LMICs (Atun et al. 2015).

Five targets have been proposed by the Radiotherapy Task Force that provides the basis for a call to action. These targets include:

- 80% of all countries should integrate radiotherapy into their cancer control plans by 2020;
- 25% increase in the 2015 radiotherapy physical infrastructure by 2025;
- training of 75,000 radiation oncologists, 20,000 radiation therapists and 6,000 medical physicists in LMICs by 2025;
- invest US\$46 billion to establish radiotherapy infrastructure and training in LMICs by 2025; and
- 80% of LMICs to include radiotherapy services as part of their universal health coverage by 2020 (Atun et al. 2015).

Other Global Commissions

Cognisant of the need to improve awareness of the global unmet need for palliative care, the Commission on Global Access to Palliative Care and Pain Relief was launched in 2014 to generate evidence by: costing an essential package of palliative care and pain relief health services; measuring the unmet need; and outlining national and global health systems strategies to expand access to palliative care and pain relief (Knaul et al. 2017). The Commission on Global Access to Palliative Care and Pain Relief has designed an essential package of palliative care medicines, human resources and training, basic equipment and cost of the essential package that could alleviate suffering associated with life-threatening and life-limiting health conditions in LMICs (Knaul et al. 2017). The Commission on Global Access to Palliative Care and Pain Relief's report provides the evidence to develop and implement solutions that recognise palliative care as a critical component of universal health coverage (Knaul et al. 2017).

Also, in 2015, the report of the Lancet Oncology Commission on Global Cancer Surgery highlighted the need to: engage civil society to highlight and educate about the importance of cancer surgery; develop cancer surgery systems and deliver a well-trained workforce; ensure that surgical services become a 2025 target; and harness and incorporate affordable technology into the surgical oncology platform (Sullivan et al. 2015).

The section above has described the wider global policy context for improving cancer control. The challenges for strengthening radiotherapy services and rationale for this doctoral project are subjects of the section below.

1.6 Strengthening access to radiotherapy services in LMICs

Radiotherapy is an essential component of effective cancer treatment and control. It is estimated that about half of cancer patients will require a radiotherapy service (Atun et al. 2015). Radiotherapy service is indicated to cure or improve local tumour control, achieve symptom control or improve the quality of life of cancer patients. Access to radiotherapy services offers opportunities to enhance cancer patient's dignity and helps create a platform to improve health outcome and wealth (Atun et al. 2015; Yap et al. 2017). Thus, improving radiotherapy services is a crucial part of achieving Sustainable Development Goals in LMICs. Unfortunately, radiotherapy service has largely been neglected in most LMICs. Like palliative care, access to radiotherapy services varies based on human development index and gross domestic product (Zubizarreta, Van Dyk & Lievens 2017). Only a third of low-income countries, half of lower middle-income countries and two-thirds of upper middle-income countries have functioning radiotherapy services (Abdel-Wahab, Fidarova & Polo 2017).

Aside from the limited availability of radiotherapy services, there are: shortage of radiotherapy workforce; high cost of radiotherapy services; poor quality of radiotherapy services; and inefficient maintenance of radiotherapy equipment (Barton, Frommer & Shafiq 2006; Rosenblatt, Acuña & Abdel-Wahab 2015). These barriers to accessing radiotherapy services often lead to: delays in receiving appropriate radiotherapy services; unmet health needs; financial burdens; and preventable deaths.

The establishment of a safe and sustainable radiotherapy service is one of the most technically difficult cancer services. A misleading belief is that the establishment of safe and sustainable radiotherapy services in LMICs is not feasible. As a result, there is a lack of political will to mobilise and allocate the necessary resources to design, implement, sustain and improve access to radiotherapy services. But with a supportive political environment, financial commitment, well-trained radiotherapy workforce and availability of other physical infrastructure, radiotherapy services can be effectively implemented and sustained irrespective of the context (Atun et al. 2015).

1.6.1 Rationale for the doctoral project

As interest in the need to improve access to radiotherapy services in LMICs has increased, researchers, international agencies and organisations have identified that LMICs vary in their ability and interest to initiate and execute plans to establish new radiotherapy services (Abdel-Wahab et al. 2017; Brown et al. 2014). Some political leaders and decision-makers do not recognise the importance of radiotherapy services. In some circumstances, LMICs' leaders may have little knowledge and understanding, as well as a lack of expertise on how to establish new radiotherapy services. Also, cancer may not be perceived as a problem in most LMICs because of certain community barriers, such as cultural norms, beliefs and practices of the community that are supportive of cancer as a spiritual disease and radiotherapy as a 'deadly and burning treatment' (Ngwa & Ngoma 2016). Hence, some LMICs have failed to invest wisely in projects to establish new radiotherapy services.

Despite the abundance of evidence for LMICs to invest wisely in initiatives to improve access to radiotherapy services, the barriers and facilitators to establishing radiotherapy services effectively in LMICs are unknown. Policy and decision-makers in LMICs need better information about which factors influence the establishment of radiotherapy services. By providing a better understanding about the establishment of radiotherapy services, this doctoral project also known as '**A**ccess to **R**adiotherapy for **C**ancer treatment (ARC) Project' fills the void in knowledge and practice about how to establish safe and sustainable radiotherapy services in LMICs.

It was assumed that establishing and sustaining a new radiotherapy service consists of multiple complex processes that overlap. Also, it was assumed that radiotherapy services are the core around which other cancer services are built. Hence, a successfully established radiotherapy service can be an important mechanism for other aspects of cancer treatment implementation. Governments, policymakers, organisations, funders, researchers and academics interested in how to establish new radiotherapy services in LMICs stand to benefit from the outcome of the ARC Project. It is expected that the ARC Project will expand the field of readiness to establish radiotherapy services by promoting discussion and further research in this area to improve access to radiotherapy services in LMICs.

Given that establishing a radiotherapy service is described as a complex concept with many different components, it is imperative to use a conceptual framework to help provide a better understanding of the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. Therefore, the next section details the two conceptual frameworks that guide the ARC Project.

1.7 Conceptual framework informing the ARC Project

Among the diverse frameworks related to health system planning, two conceptual frameworks have been identified as been relevant and informative to understanding the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, namely the: WHO's Innovative Care for Chronic Conditions Framework; and Health System Building Blocks Framework for Action (WHO 2007c; WHO 2002). Both the WHO's Innovative Care for Chronic Conditions Framework (WHO 2002) and Health System Building Blocks Framework for Action (WHO 2007c) have been successfully applied in several countries to strengthen chronic care delivery (Closser et al. 2014; Hussein et al. 2015; Mutale et al. 2016). The WHO's Health System Blocking Blocks Framework for Action was used to systematically evaluate challenges and opportunities in countries such as Nigeria, India and Nepal to ensure quality service delivery and positive effects on polio immunisation (Closser et al. 2014). The WHO's Innovative Care for Chronic Conditions Framework has been used around the world to redesign health systems as a result of community response to local needs or high-level political commitment to improve healthcare for chronic conditions, such as HIV/AIDS, diabetes and cancer (Ku & Kegels 2015; Levitt et al. 2011). In Morocco, the WHO's Innovative Care for Chronic Conditions Framework was used to identify strengths, challenges and areas for reinforcement in the current healthcare system (Semlali 2010).

The WHO's Innovative Care for Chronic Conditions Framework and Health System Building Blocks Framework for Action served as conceptual frameworks in the ARC Project to critically evaluate barriers and facilitators to establish and sustain radiotherapy services in LMICs. Articulating the two conceptual frameworks into the ARC Project helped the researcher to: address the research questions; explain keys factors that influence the establishment of a radiotherapy service; and provide understanding to establish and sustain radiotherapy services in more informed and effective ways. These two conceptual frameworks are presented in greater detail in Chapter Two.

Summary

This section has described the two conceptual frameworks – the Innovative Care for Chronic Conditions Framework and Health System Building Blocks Framework for Action – that guides the ARC Project (WHO 2007c; 2002). These two frameworks, when applied appropriately may lead to a better understanding of financial mechanisms, workforce development plan, advocacy, leadership, access to information, stakeholder engagement, technical assistance, contract negotiation and political support that enhance the successful establishment of safe and sustainable radiotherapy services.

The following section focuses on the aim, research questions and thesis outline.

1.8 Aim and research questions

The ARC Project aimed to provide practical guidance to LMICs on establishing safe and sustainable radiotherapy services.

In order to achieve the ARC Project's aim, the following research questions were asked:

- What efforts have been made to improve cancer care in LMICs and how effective have they been?
- What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs? and
- What readiness requirements do LMICs need to consider when setting out to establish safe and sustainable radiotherapy services?

1.9 Thesis outline

The thesis is composed of seven chapters, as summarised in Table 1.1. Chapter One provides a general overview of the global epidemiology of cancer, increasing burden of cancer in LMICs, services required to care for patients across the cancer care continuum and the global cancer control policy context to improve cancer control in LMICs. It also introduces the two conceptual frameworks guiding the ARC Project.

Chapter Two reports on the systematic review (Study One) conducted at commencement of the ARC Project. It discusses relevant literature on improvement strategies adopted to increase access to cancer treatment and palliative care in LMICs. Chapter Two reviews barriers and facilitators to implementing identified access improvement strategies and provides an overview of documented gaps in cancer treatment and care in LMICs. It also provides greater detail of the two conceptual frameworks guiding the ARC Project.

Chapter Three outlines the methods employed by the ARC Project for Study Two [Part A and Part B], and integration of findings. It provides details of participants, settings, data collection, data analysis and ethical approval.

Chapter Four provides the findings of a series of semi-structured interviews with global radiotherapy experts and provides an in-depth understanding of factors that influence the successful establishment of radiotherapy services in LMICs (Study Two [Part A]).

The Chapter Five reports on the mid-point meta-inference, which integrates the data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]).

Chapter Six provides the empirical findings of a participant validation process (Study Two [Part B]). The findings from the participant validation accomplished the idea of confirming or disputing

the relevance of the initial readiness items generated from the findings of Study One and Study Two [Part A].

In Chapter Seven, the conclusion and implications of the ARC Project are discussed. It also presents the readiness self-assessment guide that was developed through the integration of the ARC Project's data. Strengths and limitations of the ARC Project are also discussed.

Table 1.1: Thesis outline

Content	Chapter
Introduction to the ARC Project	One
Study One: Systematic review: • appraising strategies adopted by LMICs to improve access to cancer treatment and palliative care services; and • identifying and understanding the facilitators and barriers that contribute to the successful implementation of cancer treatment and palliative care improvement strategies in LMICs	Two
Methods and research design	Three
Study Two (Part A): Semi-structured interviews identifying and describing barriers and facilitators to establishing and sustaining radiotherapy services in LMICs	Four
Mid-point meta-inference integrating data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]) to gain a deeper understanding of the barriers and facilitators that need to be considered by LMICs planning to develop a local radiotherapy service	Five
Study Two (Part B): Participant validation process seeking feedback from global radiotherapy experts about the utility of the potential radiotherapy service development readiness assessment requirements identified via the mid-point meta-inference	Six
Conclusion and implication: Data integration and end-point meta-inference; and presentation of the 'REadiness SElf-Assessment (RESEA) Guide' for LMICs establishing safe and sustainable radiotherapy services	Seven

1.10 References

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Chapter Two: Systematic Review (Study One)

2.1 Overview

As explained in Chapter One, many LMICs are ravaged by significant socioeconomic and healthcare challenges, including a rapid escalation in NCDs, particularly cancer (Meara et al. 2015). Between 1990 and 2013, the 70% increase in cancer mortality occurred in LMICs, with 196.3 million disability-adjusted life years lost (Global Burden of Disease Cancer Collaboration et al. 2015). Globally, cancer incidence is projected to increase to 22.2 million new cancer cases by 2030, and LMICs will bear the major burden (Bray et al. 2012).

As discussed in Chapter One, the four approaches to cancer control are: prevention; early detection; diagnosis and treatment; and survivorship and palliative care. But to date, much of the focus has been on cancer prevention and early detection strategies in LMICs (Hanson et al. 2015; Raesima et al. 2015). Evidence on how to successfully implement cancer treatment and palliative care in LMICs is required to develop innovative solutions and advocate for resources to improve equity in access to cancer treatment services. Once a cancer diagnosis and staging have been confirmed, it is necessary to consider the treatment options. The aims of cancer treatment are cure, prevention of recurrence, limitation of functional disability and improvement of quality of life (palliation). Cancer treatment may involve surgery, radiotherapy, systemic anti-cancer therapies or combination of these modalities. However, most LMICs: have failed to organise cancer treatment for people living with cancer; lack adequate cancer treatment infrastructure; inadequate number of trained professionals to staff available cancer treatment services; lack access to current cancer treatment evidence; lack the technology, equipment and information system for quality cancer treatment and palliative care (de Souza et al. 2016; Knaul et al. 2011; Ngwa & Ngoma 2016).

Currently, 90% of cancer patients in low-income countries are unable to access quality surgical care (Meara et al. 2015; Sullivan et al. 2015) and a third of LMICs have no functional radiotherapy services (Abdel-Wahab, Fidarova & Polo 2017), while a fifth of those that do have only one radiotherapy machine per five million or more population (Abdel-Wahab, Fidarova & Polo 2017; Atun et al. 2015; Datta, Samiei & Bodis 2014). In most LMICs, many people present with late-stage cancer and the only treatment option is palliative care (Knaul et al. 2011; WHO 2007). Despite this burden, many LMICs are not able to provide the 52 systemic anti-cancer therapies and 22 pain and palliative care medicines on the WHO's List of Essential Medicines (Vanderpuye et al. 2017; Wirtz et al. 2017). Consequently, 80% of people living in LMICs have little or no access to pain relief (Knaul et al. 2017). Given these challenges, innovative, cost-effective, and applicable improvement strategies are urgently needed.

Most HICs able to develop, implement, sustain and scale-up strategies have made progress expanding access to cancer treatment and palliative care. Previous systematic reviews focusing on access to cancer treatment and palliative care in HICs have documented: i) facilitators that drive quality treatment outcomes, which include: strong political commitment; continuity of care; dedicated financial resources; access to educational and training opportunities; and timely recognition cancer patients' supportive care needs (Obeidat, Finnell & Lally 2011; Thompson, Cheetham & Baxi 2017); and ii) barriers, including: lack of knowledge; lack of awareness and support; competing priorities; and pervasive misconceptions about treatment quality (Chamberlain et al. 2016; Lockett et al. 2013).

Understanding barriers and facilitators across the policy, healthcare organisation and community levels of cancer treatment and palliative care services is essential to inform the design and implementation of improvement strategies in LMICs (WHO 2002a). In order to appraise strategies adopted by LMICs to improve access to cancer treatment and palliative care as well as identify the facilitators and barriers that contribute to the successful implementation, it was agreed to conduct a systematic review that focused on LMICs and the strategies that have been effective in optimising cancer treatment and palliative care services.

The systematic review was published in 2018 in the *International Journal of Public Health*. Chapter Three contains an expanded version of the findings and discussion from the publication, which is provided in Appendix C.

2.2 Publication reference

Donkor, A., Lockett, T., Aranda, S., Phillips, J.L 2018, 'Barriers and facilitators to implementation of cancer treatment and palliative care strategies in low and middle-income countries: systematic review', *International Journal of Public Health*, vol. 63, no. 9, pp. 1047–57.

2.3 Objectives

The objectives of this systematic review [Study One] were to:

- appraise strategies adopted by LMICs to improve access to cancer treatment and palliative care services; and
- identify and understand the facilitators and barriers that contribute to the successful implementation of cancer treatment and palliative care improvement strategies in LMICs.

2.4 Methods

A systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Moher et al. 2009).

The systematic review was specifically conducted to focus on care needs across the cancer care continuum. Guided by the WHO's conceptual frameworks, namely: Innovative Care for Chronic Condition Framework and Health System Building Blocks Framework for Action (WHO 2007; WHO 2002a), this systematic review collectively analysed the implementation experiences and identified barriers and facilitators of multiple cancer treatment and palliative care improvement strategies in LMICs. The application of the two conceptual frameworks was novel because they provided a robust structure for understanding several influential factors that are crucial to local circumstances and revealed meaningful themes across diverse initiatives. The details of the WHO's Innovative Care for Chronic Condition Framework and Health System Building Blocks Framework for Action are presented below (WHO 2007; WHO 2002a).

2.4.1 The WHO's Innovative Care for Chronic Conditions Framework

The first framework guiding the ARC Project is the WHO's Innovative Care for Chronic Conditions Framework (WHO 2002a). The WHO's Innovative Care for Chronic Conditions Framework is a multi-level framework that has been used successfully over the past 15 years to re-design and transform care for chronic conditions across a variety of different health systems (Epping-Jordan et al. 2004; Mayosi et al. 2009; Nuño et al. 2012). The implementation perspective of the WHO's Innovative Care for Chronic Conditions Framework emphasises essential actions at the: i) micro (patient); ii) meso (healthcare organisation and community); and iii) macro (policy) levels (WHO 2002a). Figure 2. 1 provides a diagrammatic description of the WHO's Innovative Care for Chronic Conditions Framework and its critical components are described below.

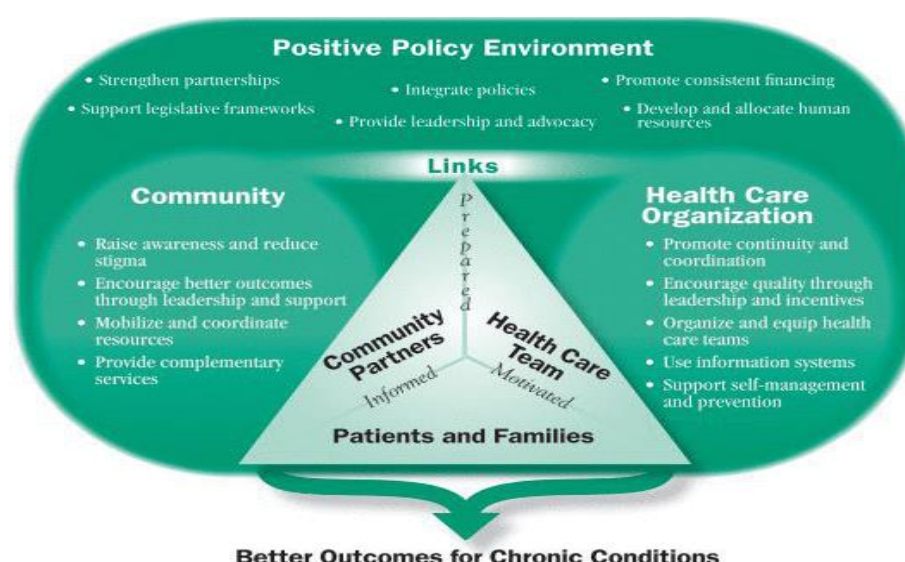


Figure 2. 1: The WHO's Innovative Care for Chronic Conditions Framework

Reproduced, with permission sought from the WHO (refer to Appendix A)

Macro-level: Building blocks for the positive policy environment

Positive policies are critical for coordinating principles, values and strategies of governments to control chronic conditions, such as cancer (WHO 2002a). Positive policy context is essential because with well-articulated policies, decision-makers can impact the health of the population (WHO 2002a). Essential components for the positive policy environment include: i) providing leadership and advocacy; ii) integrating policies; iii) strengthening partnerships; iv) supportive legislative framework; v) developing and allocating human resources; and vi) promoting consistent financing, which are described below (WHO 2002a).

Providing leadership and advocacy

Health system planning begins with the creation of a vision. Healthcare professionals, civil societies and religious leaders can influence political leaders to commit resources to advance vision to improve cancer control. Supports from political leaders are required to create positive policy environments for healthcare organisations, patients and their families, as well as communities. Advocacy and awareness strategies, such as media campaigns are important in gaining leadership support to improve care for people living with cancer (WHO 2002a).

Integrating policies

Policies are useful when they are coherent across diseases and sectors (WHO 2002a). Cancer policies and plans must be updated continually because health planning and policymaking are ongoing processes. The updates should be based on current evidence, priorities and needs of the population. Cancer policies ought to be comprehensive to include awareness, prevention, diagnosis, treatment and palliative care strategies. Policies are considered effective when they link government and community-based programmes (WHO 2002a).

Strengthening partnerships

Partnerships among governments, private and charitable sectors have the ability to impact health and improve care for people living with cancer (WHO 2002a). Cancer patients, families, religious groups, schools, local governments and professional bodies are considered important partners in cancer treatment and care delivery. It is critical to partner with different government sectors, such as agriculture, labour, transportation and education to identify policies that can improve population health while tackling economic needs (WHO 2002a).

Supportive legislative frameworks

Legislation and regulations have the potential to influence cancer control (WHO 2002a). Legislation can safeguard the rights of people living with cancer. It is considered imperative to develop and enforce regulatory frameworks to protect healthcare institutions and workers. Anti-

discrimination laws and policies can be adopted to prevent employment and housing discrimination against people living with cancer (WHO 2002a).

Developing and allocating human resources

It is considered important for educational authorities to develop or upgrade nursing, allied and medical school curricula to address the needs of people living with cancer (WHO 2002a). Ministries responsible for health and education have important connection and play a crucial role in improving care for people living with cancer. Continuous professional development mechanisms for healthcare professionals can advance care for people living with cancer (WHO 2002a).

Promoting consistent financing

Financing is a critical mechanism through which cancer policies and plans are translated into action. It is considered crucial to structure financing so that resources can be sustained. Appropriate financial mobilisation and allocation should be used to encourage the design and implementation of innovative strategies to care for people living with cancer (WHO 2002a).

Meso-level: Building blocks for the healthcare organisation

At the meso-level, the building blocks for healthcare organisation creates an environment that coordinates the delivery and evaluates the quality of the services provided (WHO 2002a). The healthcare organisation has a duty to equip healthcare personnel with the tools and expertise they need to perform their roles. Crucial components for the healthcare organisation include: i) promoting continuity and coordination; ii) encouraging quality care through leadership and incentives; iii) organising and equipping healthcare teams; iv) supporting self-management and prevention; and v) using information system, which are detailed below (WHO 2002a).

Promoting continuity and coordination

People with living with cancer require healthcare services that are coordinated across levels of providers and care. Effective communication is critical among healthcare professionals who care for people living with cancer and their families (Licqurish et al. 2019; Thorne et al. 2008). Utilising the skills and knowledge of a multidisciplinary team of healthcare professionals is important to address the complex clinical and non-clinical needs of people living with cancer and their families. Healthcare organisations ought to schedule follow-up visits to ensure continuity of cancer care (WHO 2002a).

Encouraging quality care through leadership and incentives

Support from healthcare leaders is essential for improving the care for people living with cancer. Efforts to aligning incentives for healthcare professionals and administrators are considered

critical in attracting and retaining qualified employees. Healthcare leaders play a crucial role in creating a healthcare environment that promotes quality (WHO 2002a).

Organising and equipping healthcare teams

Cancer care teams require medical equipment, essential medicines, laboratory services and medical supplies to deliver cancer care that is based on evidence. Clinical guidelines are considered important to support optimal decision making (Tsao et al. 2005). Cancer care teams require effective interpersonal and communication skills to support people living with cancer and their families to manage cancer and treatment related side effects (Berkhof et al. 2011). Cancer care teams' ability to communicate effectively is critical to promote information dissemination and shared decision-making with patients and their families. Cancer care teams ought to work collaboratively to manage people with chronic conditions (WHO 2002a).

Supporting self-management and prevention

It has been identified that people living with cancer and their families require information about self-management strategies (Warsi et al. 2004). Self-management strategies that provide cancer patients with the relevant information, skills and ability to engage help minimise complications and unavoidable consequences related to cancer and its treatment (Boger et al. 2015; Hibbard et al. 2007). Cancer care professionals play a critical role in educating people living with cancer and their families about self-management strategies (WHO 2002a). Self-management strategies for people living with cancer have been found to be related to empowerment, enhanced participation in shared decision-making, increased treatment adherence, reduced pain and fatigue, reduced psychosocial stress and increased health promoting behaviours (Boger et al. 2015; Lovell et al. 2014; McCorkle et al. 2011).

Information systems

Information systems play a crucial role in gathering, organising and disseminating data about epidemiology, treatment and outcomes. The purpose is to use the generated data to improve planning and standard of care for people living with cancer. It is considered critical to integrate a systematic approach for collecting valuable cancer patient information to inform clinical decision making (WHO 2002a).

Meso-level: Building blocks for the community

Community resources are important to the management of chronic conditions. Community services can be organised to complement healthcare organisations (WHO 2002a). To enhance care for people living with cancer, the WHO's Innovative Care for Chronic Conditions Framework defines four critical components.

Raising awareness and reduce stigma

Leaders of community-based organisations, faith-based organisations, civil societies and support groups are well-situated to create awareness and advocate for services to improve care for people living with cancer. Useful formal and informal community leaders, such as faith-based leaders can be reliable voices for informing the public about the rising burden of cancer, stress the importance of cancer prevention, early detection and treatment as well as support cancer patients to alleviate fears related to cancer (WHO Hervé 2018; Leyva et al. 2017; 2002a). Strategies to prevent stigma of cancer ought to partner with community leaders because of their respected community status (Oystacher et al. 2018). It is critical for community leaders to be knowledgeable about the burden of cancer and control strategies. Similarly, community leaders can lobby political leaders to increase support for strategies to improve care for people living with cancer (WHO 2002a).

Encouraging better outcomes through leadership and support

Identifying influential community leaders to support actions to improve care for people living with cancer is considered essential. These leaders include chiefs, queens, majors, faith-based leaders and school authorities. Credible community groups or organisations can advocate for quality care for people with living with cancer. Community leaders are perfectly positioned to provide social support services for people living with cancer (WHO 2002a).

Mobilising and coordinating resources

Community leaders can be inspired to raise funds to support the training of community health workers and health promotion and prevention campaigns. Community leaders and groups can also be mobilised to generate funds to support the purchase of basic essential equipment, medical supplies and transport scheme programme to assist people living with cancer (WHO 2002a).

Providing complementary services

Community volunteers and health workers are informal networks of providers who are valuable in the cancer prevention and control (Bittencourt & Scarinci 2019). Community health workers can be used to build a link between the community and the healthcare organisation. Community health workers can also be trained to provide basic health services, such as navigators for people living with cancer (WHO 2002a).

Micro-level: Building blocks at the patient interaction level

Positive outcomes from cancer treatment can be attained when patients and their families, community partners and cancer care teams are informed, motivated, prepared and work together (WHO 2002a). The WHO's Innovative Care for Chronic Conditions Framework

recognises that people living with cancer and their families become active participants in their care when each level of the healthcare system are integrated. People living with cancer and their families ought to be informed about their cancer diagnosis, including: expected complications; and strategies to prevent complications and manage symptoms. Similarly, people living with cancer and their families ought to be prepared with skills, necessary medicines, self-monitoring tools and medical equipment to participate in the management of cancer home (WHO 2002a).

2.4.2 The WHO's Health System Building Blocks Framework for Action

The second framework guiding the ARC Project is the WHO's Health System Building Blocks Framework for Action (WHO 2007). The WHO's Health System Building Blocks Framework for Action defines the desired attributes of a health system. The WHO's Health System Building Blocks Framework for Action also provides ways to identify gaps that may exist in a health system (WHO 2007). The WHO's Health System Building Blocks Framework for Action consists of six building blocks, namely: i) service delivery; ii) health workforce; iii) information; iv) medical products, vaccines and technologies; v) financing; and vi) leadership and governance (WHO 2007) (refer to Figure 2. 2).



Figure 2. 2: The WHO's Health System Building Blocks Framework for Action

Reproduced, with permission sought from the WHO (refer to Appendix B)

Since the development of the WHO's Health System Building Blocks Framework for Action, most Member States of WHO, the United States of America President's Emergency Plan for AIDS Relief and other international organisations have placed importance on the organisation, prioritisation and implementation of healthcare improvement strategies in the six areas of strengthening health systems (Adam et al. 2011; Bigdeli et al. 2013; Lohman et al. 2017). The six building blocks within the Health System Building Blocks Framework for Action are described below.

Service delivery

Appropriate and responsive service delivery is considered critical to address the needs of people living with cancer and their families. Appropriate and responsive cancer services are those which provide safe, timely and quality care to those that need it with minimum waste (WHO 2007). Appropriate and responsive cancer services can be delivered in the: home, community; workplace; or health facilities. The service delivery building block of the Health System Building Blocks Framework for Action highlights the importance of understanding the demand for services, developing integrated services, infrastructure and logistics, organisation of provider networks and good management to ensure access to quality, safe and continuous care across the cancer care continuum and different locations (WHO 2007).

Information

The strategic use of cancer information, research and intelligence are critical in governing and managing cancer care services. A well-functioning cancer information system is one that ensures the production, analysis, dissemination and use of accurate and reliable cancer information by policy- and decision-makers (WHO 2007). The cancer information system ought to have the capacity to: generate population and facility-based data; detect, investigate, communicate and contain events that threaten public health security; and analyse information and promote the accessibility of knowledge (WHO 2007).

Health workforce

Cancer care workforce are committed people engaged in actions to protect and improve the health and wellbeing of people living with cancer. A well-performing cancer care workforce is one which is available, responsive, competent and productive (WHO 2007). A country-wide plan is considered critical to manage workforce dynamics and improve distribution. Similarly, a regulatory authority is required to maintain the quality of education and practice. Continuous investment in cancer care workforce development is essential to address critical shortages of workers, scale-up numbers of workers in a sustainable manner (WHO 2007).

Financing and social protection

A well-functioning health system has the capacity to raise adequate funds for health to protect people living with cancer and their families from financial hardship related to paying for the needed cancer services. There is no single model for health financing (WHO 2007). Most health financing includes a mix of public, private and goodwill financing and provision. Generating enough funds, promoting accountability and transparency and effective allocation of resources are critical principles to sustain health financing (WHO 2007).

Medical products, vaccines and technologies

A well-performing health system is one which ensures equitable access to essential medicines, vaccines and technologies (WHO 2007). Countries ought to have national policies, standards, guidelines and regulators to ensure quality medical products, vaccines and technologies. Having procurement, storage, supply and distribution systems are crucial to minimising waste. To achieve cost-effectiveness, countries ought to have access to information on prices and the capacity to set and negotiate prices of medical products, vaccines and technologies (WHO 2007).

Leadership and governance

There is no clear plan for good health leadership and governance. Governments have the responsibility of overseeing and guiding the health system to protect the public interest. Health leaders ought to design regulations and incentives, develop health policies, provide intelligence and oversight, build collaborations and coalitions and ensure transparency to achieve health system performance and meaningful accountability (WHO 2007).

2.4.3 Eligibility criteria

Included studies were: all conducted in countries categorised by the World Bank Group (2017) Classification as being 'low income', 'middle income', 'developing', 'less-resourced' or 'limited resourced'; published in an English peer-reviewed journal since 1990; reporting empirical data related to the impact of a strategy, intervention or programme designed to improve access to surgery, radiotherapy, systemic anti-cancer therapies and/or palliative care. An 'access improvement strategy' was defined as any programme, plan, intervention or policy implemented to ensure cancer surgery, radiotherapy, systemic anti-cancer therapies, other essential cancer medicines, and/or palliative care services were more available, accessible, adequate, affordable, and appropriate. Studies focusing exclusively on cancer prevention or early detection were excluded.

2.4.4 Information sources and search strategy

Search terms were devised from relevant Cochrane Reviews (Dudley & Garner 2011; Kredo et al. 2013). A combination of Medical Subject Headings (MeSH) and keywords for LMICs, cancer, treatment modalities and healthcare delivery were used. Appendix D shows the detailed search strategy.

Between 4th April and 6th May 2017, three electronic databases – MEDLINE (EBSCO), CINAHL (EBSCO) and the Cochrane Library, were searched for relevant articles. These were selected, as they provide indexing for extensive international journals and regularly updated with relevant

resources covering health topics. Reference lists of relevant articles were hand-searched to identify additional articles. Articles were exported to and managed in EndNote X8 software.

2.4.5 Study selection

After removal of duplicates, all titles and abstracts were screened against the eligibility criteria (AD). Ten percent of the articles were screened by a second reviewer (TL), with 98.5% agreement being reached. Ineligible articles were removed. Full-text of all potentially relevant articles were retrieved, and further eligibility and quality assessments were undertaken by AD alone, with discussions among the wider team as necessary.

2.4.6 Data items and collection process

Data were extracted into a standardised data collection form using Microsoft Excel 2016 (AD) guided by a modified Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) tool (Ogrinc et al. 2016).

2.4.7 Quality assessment

The quality of the studies was also assessed based on SQUIRE (AD). The Australian National Health and Medical Research Council approved rating system was used to rank the level of evidence.

2.4.8 Synthesis

Due to the range of designs and outcomes involved, a narrative synthesis using approaches described by Popay and colleagues (2006) was adopted. Included studies were independently coded by two reviewers (AD and TL) to map strategies against the WHO's conceptual frameworks, namely: Innovative Care for Chronic Condition Framework and Health System Building Blocks Framework for Action (WHO 2007; WHO 2002a). Any discrepancies were resolved through discussion.

2.5 Results

The initial search identified 3063 articles, with another six identified during hand searching. After removal of duplicates and screening, 138 articles underwent a full-text review. Nineteen articles met the inclusion criteria, with one study reported across two publications (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondra & Garcia-Gonzalez 2009) (refer to Figure 2.3).

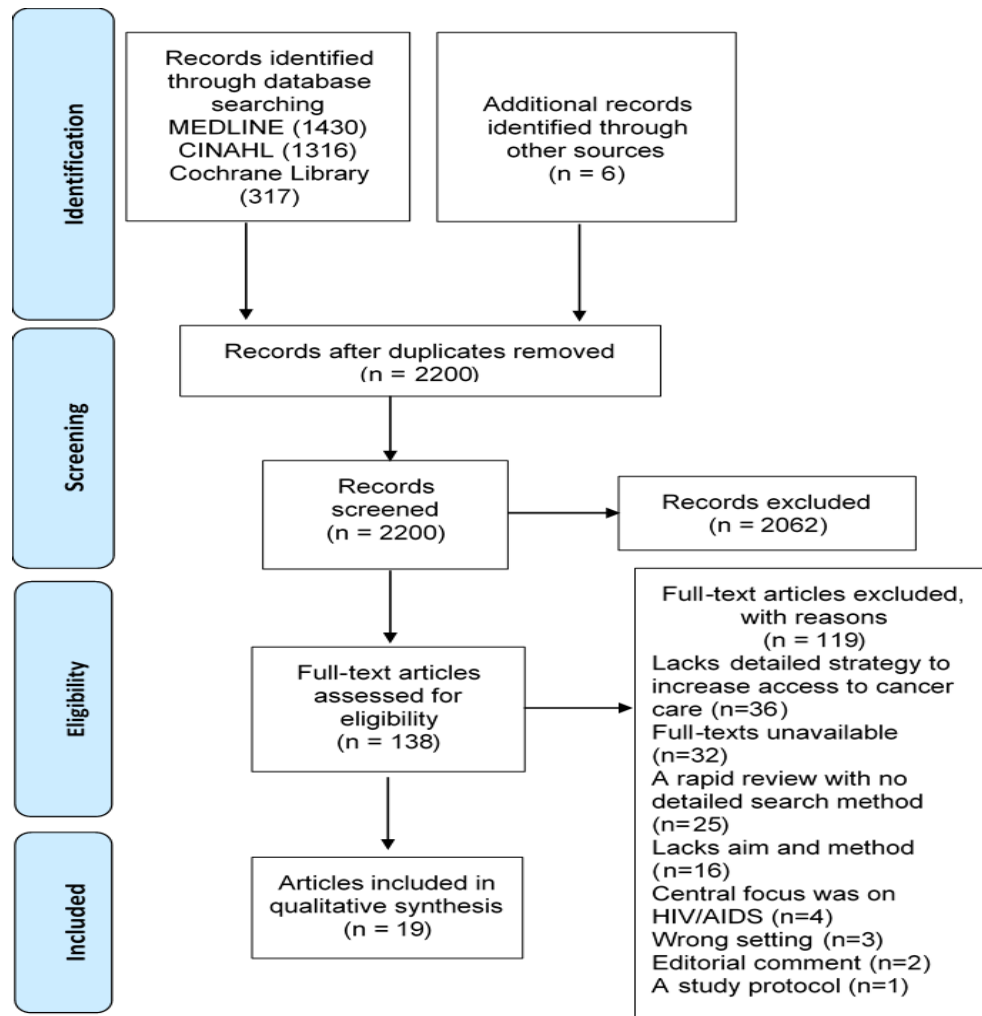


Figure 2.3: Flow diagram illustrating study search and selection in the systematic review

2.5.1 Study characteristics

Evidence on strategies for increasing access to cancer treatment and palliative care came from 12 different LMICs, mostly African nations.

The majority of studies (61%, n=11) focused on increasing palliative care access (Ali 2016; Banerjee 2009; Boit et al. 2014; Gafer & Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Paiva et al. 2012; Shamieh & Hui 2015; Tapsfield & Bates 2011; Wang et al. 2013), while a fifth (22%, n=4) focused on strengthening radiotherapy services (Agrawal et al. 2011; Efsthathiou et al. 2016; Einck et al. 2014; Galalae et al. 2015). A tenth (11% n=2) focused on improving integrative cancer care (Brown et al. 2017; Nwogu et al. 2016), and only one study focused on improving anti-cancer drug access (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009).

2.5.2 Quality assessment

Apart from one (Wang et al. 2013) randomised controlled trial (RCT), with high cross-group contamination, the studies all generated low-level evidence predominately from case reports (n=11, 61%) (Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015; Krakauer et al. 2015; Nwogu et al. 2016; Shamieh & Hui 2015). Overall, the studies were of poor quality. None were underpinned by a conceptual framework or theory; two-thirds (67%, n=12) did not evaluate the strategy (Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014; Garcia-Gonzalez, Boulton & Epstein 2015; Krakauer et al. 2015; Nwogu et al. 2016; Shamieh & Hui 2015; Tapsfield & Bates 2011); 44% (n=8) did not describe the methods (Boit et al. 2014; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015; Krakauer et al. 2015; Shamieh & Hui 2015); and less than a third (n=5) had secured ethics approval (Galalae et al. 2015; Herce et al. 2014; Paiva et al. 2012; Tapsfield & Bates 2011; Wang et al. 2013).

2.5.3 Identified efforts to improve cancer care in LMICs

The systematic review (Study One) identified several efforts to improve cancer care in LMICs. Strategies adopted by LMICs are summarised further down the Chapter in Table 2.1 and are discussed in detail below. A large number of the identified efforts included: multi-sectoral partnerships initiative; training and educational initiatives; research improvement through collaborations; and global and community mobilisation of resources.

Multi-sectoral partnerships initiative

Multi-sectoral partnerships are now built into the design of a variety of strategies to improve cancer care in LMICs. Often, multi-sectoral partnerships initiative involving the public, civil society organisations and/or private sector provide: funding; human resources; awareness and advocacy; and technical assistance to support radiotherapy, palliative care and integrated cancer care improvement (Agrawal et al. 2011; Ali 2016; Brown et al. 2017; Efstathiou et al. 2016; Nwogu et al. 2016). Multi-sectoral partnerships initiative is often achieved through leadership, as well as meaningful and inclusive stakeholder engagement in each step of the partnership process. For instance, by strengthening multi-sectoral partnerships, over 30,000 patients have accessed palliative care services in Kenya. Consistent funding from international partners enables in-country training of healthcare professionals to provide palliative care for more people and their families (Ali 2016).

Training and educational initiatives

Several studies acknowledged that to mitigate brain drain and promote sustainability of human resources, governments, civil society organisations and international agencies have been mobilising and allocating resources toward training and educational programmes for cancer specialists in LMICs (Agrawal et al. 2011; Efstathiou et al. 2016). Tele-education initiatives have been developed in some LMICs and tailored to various health literacy and cancer care workforce needs to promote acceptance and participation (Agrawal et al. 2011). Another workforce capacity building initiative is the 'train-the-trainer'. Train-the-trainer programmes are unique collaborations with host LMIC radiotherapy centre and experts from HICs (Einck et al. 2014). The primary purpose of train-the-trainer programme is to help build radiotherapy workforce capacity in LMICs through a sustainable and scale-up mechanism. Deploying qualified and committed radiation oncologists, radiation therapists and medical physicists for one month or even more than one year to work as volunteers, alongside local radiotherapy staff to train the workforce in a locally tailored and culturally appropriate environment is a key characteristic of train-the-trainers programmes (Einck et al. 2014; Galalae et al. 2015).

Research improvement through collaborations

It was identified that international research collaborations have been formed to promote capacity building for research to effectively measure outcomes of new technologies implemented to improve radiotherapy services (Efstathiou et al. 2016; Einck et al. 2014; Galalae et al. 2015). One example is the collaboration between Christian-Albrechts-University Kiel in Germany and Chiang Mai University in Thailand, which is an academic health institution research collaboration to improve quality and safe delivery of radiotherapy services in the LMIC (Galalae et al. 2015). This research collaboration involving radiation oncologists and medical physicists from both a HIC and LMIC have implemented image-guided gynaecological brachytherapy to determine which interventions are effective in ensuring disease free survival in cervical cancer patients (Galalae et al. 2015). For research efforts, there is an acknowledgment that data collection, analysis and dissemination needs improvement in LMICs. As a result, international agencies, such as International Agency for Research on Cancer are working to optimise cancer data capturing in LMICs through advocacy, training, provision of resources; and technical assistance to design and implement cancer registries (Efstathiou et al. 2016).

Global and community mobilisation of resources

It was identified that HICs governments, global cancer leaders and international agencies/organisations have been developing cancer control initiatives that are evidence-based with partners institutions in LMICs to improve cancer care (Brown et al. 2017; Einck et al. 2014; Gafer & Elhaj 2014). International agencies/organisations that have assumed leadership roles in improving cancer care in LMICs include: WHO; UICC; IAEA; International Agency for Research

on Cancer; Radiating Hope; and Worldwide Hospice Palliative Care Alliance. It was also identified that regional and/or community organisations, such as the African Palliative Care Association and Kenya Hospices and Palliative Care Association have been carrying out capacity-building activities on a participatory basis to improve cancer care, particularly palliative care services (Ali 2016; Boit et al. 2014; Gafer & Elhaj 2014). Global and community mobilisation efforts vary based on the LMIC's cancer care needs. However, global and community mobilisation strategies that address palliative care include: providing leadership and advocacy; promoting consistent financing; organising and equipping healthcare professionals with essential medicines such as morphine; promoting palliative care education; and enhancing patient's capacity for self-management (Ali 2016; Herce et al. 2014; Krakauer et al. 2015; Tapsfield & Bates 2011). A large-scale collaborative effort was the reviewing of national opioid policies in Vietnam, which resulted in an increased in morphine consumption from 0.06 to 0.46 mg/year (Krakauer et al. 2015).

Table 2.1: Studies describing strategies adopted to improve access to cancer treatment and palliative care in LMICs, 1990-2017

Research Question One: What efforts have been made to improve cancer care in LMICs and how effective have they been?				
Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
Brown (2017)*, 2015-2018	To describe the “Edinburgh Malawi Breast Cancer Project” initiative which started in 2015. Case report. Level IV.	Setting: Integrated cancer care (Chemotherapy, Surgery and Palliative Care) at a Tertiary hospital. Participants: Breast cancer nurse specialists (n=1) Other team members (n=2); Pathology technicians (n=2); Data management team (n=unknown).	Positive policy environment: - Strengthen partnership (partnership with academic health institutions); - Promote consistent financing (financial assistance from foreign government with an amount of £185K); - Develop and allocate human resources (Specialist breast cancer nurse role); Healthcare Organisations: - Promote continuity and coordination (Breast cancer MDT meeting) and; - Organise and equip healthcare team (Breast cancer educational programme, Estrogen Receptor testing); and - Use information systems (a clinical data management system).	Strategies implemented but not evaluated.
Nwogu (2016), Nigeria; 2009	The establishment of a nongovernmental organization (NGO) to stimulate the development of partnerships among oncology professionals, private enterprise, and academic institutions. Case report. Level IV.	Setting: Integrated cancer care (Chemotherapy, Surgery and Palliative Care) at a Secondary hospital. Participants: Health and non-healthcare professionals (n=unknown).	Positive policy environment: - Strengthen partnership (Partnership with a private enterprise, and collaborations with multiple academic health institutions); - Consistent financing (private sector providing financial support with an unknown amount); - Provide leadership and advocacy (establishment of an NGO); - Develop and allocate human resources (one-off cancer control capacity building workshop) Healthcare organisation: - Promote continuity and coordination (clinical MDT meeting);	Between 2014 and 2016, there was 17.4 % average annual increased in patients’ access to the cancer centre.

Research Question One: What efforts have been made to improve cancer care in LMICs and how effective have they been?

Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
			- Organise and equip healthcare team (establishment of a comprehensive cancer centre); - Use information systems (a clinical data management system); Community: - Mobilise and coordinate resources (coordinating community institutions and accessing funds).	
Efstathiou (2016)*, Botswana; Late 1990s	To outline a system approach and series of key questions to direct strategy toward establishing quality radiation services and highlight the story of private-public investment in Botswana from the late 1990s to the present. Case report. Level IV.	Setting: Tertiary hospital (Radiotherapy). Participants: Staff strength (n>30).	Positive policy environment: - Strengthen partnership (public-private partnership); - Promote consistent financing (private sector providing treatment and government funding treatment cost); - Develop and allocate human resources (out-of-country training for radiation oncologists); Healthcare organisation: - Organise and equip healthcare team (installed linear accelerator). - Population-based cancer registries with technical support from International Agency for Research on Cancer	Between 2001 and 2014, there was 4% average annual increase of patients treated with radiotherapy.
Ali (2016), Kenya; 2010	To provide palliative care services for more patients and their families. Case report. Level IV.	Setting: Secondary hospital (Palliative care). Participants: Healthcare professionals (n=220); Provincial hospitals (n=11).	Positive policy environment: - Strengthen partnership (public-non-profit partnership); - Promote consistent financing (international grant with Phase I: £120K and Phase II: £175K); - Provide leadership and advocacy (Advocacy for the MoH to procure morphine);	Within a year over 30,000 patients accessed palliative care services.

Research Question One: What efforts have been made to improve cancer care in LMICs and how effective have they been?

Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
			- Develop and allocate human resources (in-country training of healthcare professionals); Healthcare organisation: - Promote continuity and coordination (nurse coordinators); - Organise and equip healthcare team (integration of palliative care services into 11 provincial hospitals); Community: - Mobilise and coordinate resources (mobilisation of community volunteers).	
Shamieh (2015), Jordan; Not stated	To describe the King Hussein Cancer Centre palliative care programme and its integration into the oncology setting to optimise care delivery for patients with cancer. Case report. Level IV.	Setting: Tertiary hospital (Palliative Care). Participants: 2012 staff strength included palliative care physicians (n=3), home care nurses (n=4), social worker (n=1), clinical pharmacists (n=2) and medical residents (n=3); Total patient consultations at the inpatient clinic (n=400); Total patient admissions at the 8 beds inpatient unit (n=979); Home care enrolment (n=658): (n=177 initial visits, n=1031 routine follow-up visits, n=156 crisis visits); Bereavement visits (n=137).	Positive policy environment: - Develop and allocate human resources (in-country training for healthcare professional); Healthcare organisation: - Promote continuity and coordination (nurse coordinator); - Organise and equip healthcare team (provided healthcare professionals with essential pain medicines); - Support self-management and prevention (provided patients and family members with skills).	Palliative care strategies implemented but not evaluated.

Research Question One: What efforts have been made to improve cancer care in LMICs and how effective have they been?

Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
Lal (2015), India; Not stated	To describe a number of novel palliative care steps that have been taken to respond to our patients diverse and serious needs. Retrospective Review. Level IV.	Setting: Tertiary hospital (Palliative care). Participants: Total patients clinically evaluated (n=156); Males (n=87); Mean age ($\bar{x}$ =41.5, SD=unknown); Urban habitants (n=111).	Healthcare organisation: - Organise and equip healthcare team (provided healthcare professionals with essential pain medicines); - Support self-management and prevention (provided patients and family members with skills).	Reduction in VAS score (p-value <0.01).
Krakauer (2015)*, Vietnam; 2006	To report progress toward eliminating barriers to opioid accessibility in Vietnam, using a balanced policy method, developed by the Pain & Policy Studies Group. Case report. Level IV.	Setting: Nationwide (Palliative care). Participants: Ministry of Health officials (n=2).	Positive policy environment: - Strengthen partnership (partnership with multiple local sectors); - Integrate policy (reviewed national opioid policies); - Support legislative framework (regulations on the accessibility and prescription of opioids); - Provide leadership and advocacy (organised workshops on opioid policy); - Develop and allocate human resources (out-of-country fellowship on pain and policy); Healthcare organisation: - Organise and equip healthcare team (accessibility of essential pain medicines).	Between 2003 and 2010, there was an increased in morphine consumption from 0.06 to 0.46 mg/year; Increased in palliative care service from 3 to 15 over same.
Garcia-Gonzalez (2015)*, General; 2001-current	To describe the structure of the Glivec International Patient Assistance Programme (GIPAP), as well as important	Setting: LMICs (Chemotherapy). Participants: Total GIPAP patients in 2015 (n=49,484);	Positive policy environment: - Strengthen partnership (private-non-profit partnership); - Promote consistent financing (financial assistance from an industry with an unknown amount); Healthcare organisation:	80 countries have benefited from the access strategy;

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	lessons that have contributed to the success of the program. Case report. Level IV.	Mean age ($\bar{x}$=unknown, SD=unknown); Total number of GIPAP physicians (n=1,502).	- Organise and equip healthcare team (free donation of imatinib to eligible cancer patients); - Support self-management and prevention (peer-to-support).	Free access to imatinib with 2.3 million doses monthly.
Kanavos (2009)*, General; 2001-current	To identify and discuss the socio-economic and demographic characteristics of the patients participating in GIPAP and analyse the impact the programme is having on health outcomes. Retrospective Review. Level IV.	Setting: LMICs (Chemotherapy). Participants: Total patients (n=13,568); Males (n=8,453); Mean age ($\bar{x}$=38.7, SD=unknown).	Positive policy environment: - Strengthen partnership (private-non-profit partnership); - Promote consistent financing (financial assistance from an industry with an unknown amount); Healthcare organisation: - Organise and equip healthcare team (free donation of imatinib to eligible cancer patients); - Support self-management and prevention (peer-to-support).	Between 2005 and 2007, survival rate was 66%.
Galalae (2015)*, Thailand; 1999-current	To describe an exchange programme of researchers and clinicians/physicists between two universities that led to the development of image-guided brachytherapy. Case report. Level IV.	Setting: Tertiary hospital (Brachytherapy). Participants: Researchers, radiation oncologists and medical physicists (n=unknown).	Positive policy environment: - Strengthen partnership ((partnership with academic health institutions); - Develop and allocate human resources (international exchange programme); Healthcare organisation: - Organise and equip healthcare team (develop image-guided brachytherapy protocols for cervical cancer).	Strategies implemented; and 19 months follow up revealed 93.1% local control, 86.2% disease-free survival, and 96.6% overall survival in 29 cervical cancer patients.

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Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
			Promote international research collaboration to improve quality and safe radiotherapy service	
Herce (2014), Malawi; 2011	To report the results of a situation analysis, including early outcomes from the Neno Palliative Care Programme. Retrospective cohort study. Level III-2.	Setting: Secondary hospital (Palliative care). Participants: Health team included physician (n=1), clinical officers (n=2), palliative care coordinator (n=1), nurse (n=1), community health workers (n=691) and MoH home-based care volunteers (n=150); Total number of patients enrolled from January to October 2012 (n=63); Mean age ($\bar{x}$=48, SEM=2.2); Number of cancer patients (n=50); Total number of consultations at the outpatient palliative clinic (n=57); inpatient clinic (n=32); home care (n=22).	Positive policy environment: - Strengthen partnership (public-non-profit partnership); - Promote consistent financing (international grant with an amount of £20K); Healthcare organisation: - Promote continuity and coordination (nurse coordinators and community health workers); - Organise and equip healthcare team (integration of palliative care service); - Support self-management and prevention (provided patients and family members with skills to monitor symptoms); Community: - Better outcome through leadership and support (collaboration with local community-based and faith-based organisation); - Mobilise and coordinate resources (engaging community leaders and volunteers); - Provide complementary services (providing counselling and socioeconomic supports).	Reported pain score; Non-significant decreased between baseline and follow-up pain score (p-value=0.5); Patient received psychosocial supports, but no baseline data provided.

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Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
Gafer (2014), Sudan; 2010	To review the current state of services and progress in education of palliative care for cancer patients in Sudan. Retrospective Review. Level IV.	Setting: Tertiary hospital (Palliative care). Participants: Trained clinicians (n=30); Total patients evaluated at the outpatient clinic from 2010 to 2014 (n=1,249); Males (n=525); Mean age ($\bar{x}$ =51, SD=unknown); Total patients evaluated at the inpatient clinic from 2011 to 2014 (n=680); Total patients visited at home (n=344).	Positive policy environment: - Promote consistent financing (international grant with unknown amount); - Provide leadership and advocacy (lectures on palliative care by international and local healthcare professionals); - Develop and allocate human resources (in-country training of healthcare professionals); Healthcare organisation: - Promote continuity and coordination (nurse coordinator); - Organise and equip healthcare team (Integration of palliative care services into an oncology setting); - Support self-management and prevention (provided patients and family members with skills to monitor symptoms); Community: - Raise awareness and reduce stigma (community participatory).	Strategies implemented but not evaluated.
Einck (2014)*, Senegal; 2012	To implement a high-dose-rate brachytherapy programme for carcinoma of the cervix in Senegal. Case report. Level IV.	setting: Tertiary hospital (Brachytherapy). Participants: Senegal radiotherapy staff strength included: radiation oncologists (n=2), radiation therapists (n=2) and medical physicists (n=3); Volunteer medical team from Global Radiation Oncology Workforce include radiation	Positive policy environment: - Strengthen partnership (public-non-profit partnership); Healthcare organisation: - Organise and equip healthcare team (donation of high-dose-rate brachytherapy equipment, and development of treatment protocol).	Strategies implemented but not evaluated.

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Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
		oncologists (n=2), medical physicists (n=2), radiation oncology resident (n=1), and radiation oncology nurse (n=1)		
Boit (2014), Kenya; 2009-current	To describe how Kimbilio Hospice started, the impact it has made in the community, and how it works with local and national hospitals and organizations to improve care throughout Kenya. Case report. Level IV.	Setting: Secondary hospital (Palliative care). Participants: Trained clinicians (n=unknown); Total patients admitted in 2013 at Kimbilio (n=229); Males (n=94); Mean age, ($\bar{x}$ =unknown, SD=unknown).	Positive policy environment: - Promote consistent financing (international donations and grants with unknown amount); - Develop and allocate human resources (in-country training for healthcare professionals); Community: - Raise awareness and reduce stigma (community participatory); - Provide complementary services (spiritual services).	No evaluation.
Wang (2013), China; 2011-2012	To evaluate clinical pharmacist-led pain-medication education in patients with cancer. Randomised controlled trail (RCT). Level II.	Setting: Tertiary hospital (Palliative care). Participants: Total participants (n=237); Control group (n=114), Males (n=83); Intervention group (n=123), Males (n=84); Mean age, ($\bar{x}$ =51.3, SD=unknown).	Healthcare organisation: - Support self-management and prevention (patient information booklet on pain management); Community: - Raise awareness and reduce stigma (patient education by a clinical pharmacist).	Patients' knowledge on cancer pain and pain control with analgesics significantly increased in both the control and education groups (p-value<0.05); Significant reduction in the slope of pain intensity in the education group (p-value<0.05).
Paiva (2012), Brazil; 2010	To obtain preliminary data on the effectiveness of a palliative care outpatient programme in	Setting: Tertiary hospital (Palliative care).	Positive policy environment: Develop and allocate human resources (in-country training for nurses);	Significant improvement in symptoms (p-value>0.0001).

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Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
	improving cancer-related symptoms. Retrospective Review. Level IV.	Participants: Total patients clinically evaluated (n=232); Males (n=120); Mean age ($\bar{x}$ =58.9, SD=12.8).	Healthcare organisation: Support self-management and prevention (provided patients with skills to monitor symptoms).	
Tapsfield (2011), Malawi; 2003	To review a six months in- patient palliative care services at Tiyanjane Clinic. Retrospective Review. Level IV.	Setting: Tertiary hospital (Palliative care). Participants: Total patients clinically evaluated (n=137); Males (n=79); Mean age ($\bar{x}$ =39.1, SD=unknown).	Positive policy environment: - Promote consistent financing (international grant and government support with an amount of £10K); - Develop and allocate human resources (in-country training for healthcare professionals); Healthcare organisation: - Organise and equip healthcare team (integration of palliative care service).	Mean total daily dose of morphine ($\bar{x}$ =30 mg, SD=unknown).
Agrawal (2011), India; 2004-unknown	To present the design, implementation, and a two-year audit of tele-education activities. Case report. Level IV.	Setting: Tertiary hospital (Radiotherapy). Participants: Resident radiation oncologists (6-8 participants at the remote centre and 16-20 participants at the host centre).	Positive policy environment: - Strengthen partnership (public-academic health institution partnership); - Promote consistent financing (financial support from government with an amount of £83K); - Provide leadership and advocacy (lecture by radiation oncologist at the government level); - Develop and allocate human resources (training of resident radiation oncologists via telemedicine); Healthcare organisation:	Strategies implemented; auditing revealed 59.2% successfully transmitted sessions.

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Author (Year), Implementation Year(s)	Aim, Study Design and Level of Evidence	Setting and Participants	Strategies as per ICCCF levels	Outcomes
Banerjee (2009), India; 1996	To review the effectiveness of home care team visit in terminal cancer patients. Retrospective Review. Level IV.	Setting: Secondary hospital (Palliative care). Participants: Total patients visit from 2008 to 2009 (n=1,025); Total home visits (n=722) Mean age ($\bar{x}$ =unknown, SD=unknown)	- Organise and equip healthcare team (specialist radiation oncology knowledge and skills). Positive policy environment: - Develop and allocate human resource (in-country training); Healthcare organisation: - Organise and equip healthcare team (healthcare professionals provided with essential pain medicines); - Support self-management and prevention (providing patients with skills to monitor symptoms).	Strategies implemented but not evaluated

Legend: *First author's institution located in a high-income country; Innovative Care for Chronic Conditions Framework–ICCCF; Standard Deviation–SD; Standard Error of Mean–SEM; Visual Analogue Scale–VAS; Glivec International Patient Assistance Programme–GIPAP; Non-Government Organisation–NGO; Multidisciplinary Team–MDT; Thousand–K; Ministry of Health–MOH; Mean– $\bar{x}$

Summary

The section above has described the efforts undertaken to improve cancer care in LMICs. The next section reports the facilitators and barriers to implementation of cancer treatment and palliative care strategies in LMICs.

2.5.4 Identified facilitators and barriers to implementation of cancer care strategies

The section above has described the efforts undertaken to improve cancer care in LMICs. Several facilitators and barriers to implementation of cancer treatment and palliative care were identified, which were organised into the three domains of the WHO's Innovative Care for Chronic Conditions, namely: positive policy environment; healthcare organisation; and community. The section below reports in detail the facilitators and barriers (refer to Table 2.2).

Positive policy environment facilitators and barriers

Seven main positive policy environment facilitators emerged as being crucial to the successful implementation of the access improvement strategies Stakeholder engagement (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015; Herce et al. 2014; Kanavos, Vondoros & Garcia-Gonzalez 2009; Krakauer et al. 2015; Nwogu et al. 2016; Tapsfield & Bates 2011) and financial support (Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Gafer & Elhaj 2014; Garcia-Gonzalez, Boulton & Epstein 2015; Herce et al. 2014; Kanavos, Vondoros & Garcia-Gonzalez 2009; Nwogu et al. 2016; Tapsfield & Bates 2011) were identified as critical facilitators across all access improvement strategies implementation. Embedding a shared understanding of the project importance and the proposed action(s) and facilitating a sense of co-creation and ownership, were the key primary focus of the stakeholder engagement strategies implemented across the projects. Through the co-creation of a cancer centre, there was an estimated 17% average annual increase in cancer patients accessing care which was observed between 2014-2016 (Nwogu et al. 2016).

Five key positive policy environment barriers that impeded the implementation of the planned access improvement strategies were identified. Across four studies, lack of human resources was the most critical barrier to the implementation of cancer improvement strategies (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014). Several studies acknowledged financial constraints and a lack of political commitment as major barriers to implementation (Ali 2016; Nwogu et al. 2016). Collectively these identified barriers contributed to: strategy implementation delays (Ali 2016; Gafer & Elhaj 2014); high health professionals workloads (Efstathiou et al. 2016; Einck et al. 2014); and patients experiencing long waiting times to be seen by health professionals (Brown et al. 2017; Nwogu et al. 2016).

Healthcare organisation facilitators and barriers

Of the eight healthcare organisation facilitators identified, creating a supportive learning environment was key to increasing integrated cancer care, radiotherapy, and/or palliative care access. Thirteen studies with varying levels of evidence reported creating a supportive learning environment for health professionals to develop specialist and generalist knowledge and skills (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Gafer & Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh & Hui 2015; Tapsfield & Bates 2011). The RCT reported a significant increase in patients' knowledge of cancer pain and pain control by employing a task-shifting strategy ($p < 0.05$) (Wang et al. 2013). Few studies targeted financial hardship and treatment adherence by offering free access to essential cancer and palliative care medicines (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009; Lal et al. 2015). While a significant increase in survival could not be determined in a retrospective review of the outcome of the free drug donation strategy, a three-year survival rate of 66% was reported among 13,568 patients (Kanavos, Vondoros & Garcia-Gonzalez 2009). Access improvement strategies tailored to local resources and conditions generated better acceptance of the changes (Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015).

Ten healthcare organisation barriers to access improvement strategies implementation were identified, with the majority related to radiotherapy access, such as: limited physical infrastructure (Efsthathiou et al. 2016; Einck et al. 2014); lack of radiotherapy equipment (Efsthathiou et al. 2016; Einck et al. 2014); and radiotherapy equipment maintenance difficulties (Efsthathiou et al. 2016). Untimely delivery of appropriate radiotherapy doses was a major negative consequence. The most challenging aspect of systemic anti-cancer therapies access improvement strategies were: poor internet connectivity, identifying and verifying eligible cancer patients, as well as maintaining communication between strategy providers and health professionals (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009). While a small number of studies suggested that prohibitive cancer treatment cost limited access for cancer patients and their families (Einck et al. 2014; Nwogu et al. 2016), no economic evidence estimating the direct and indirect treatment costs was provided.

Community facilitators and barriers

Two community facilitators that supported the successful implementation of integrative cancer care and palliative care access improvement strategies were identified (Boit et al. 2014; Herce et al. 2014; Nwogu et al. 2016). Across two studies, community networks were important providers of complementary services, such as socioeconomic supports (Boit et al. 2014; Herce et al. 2014). A critical facilitator was mobilising and coordinating community resources. One study acknowledged that established civil society organisations offered unique opportunities to

mobilised funds and coordinated with other community institutions to foster greater community buy-in of improvement strategies (Nwogu et al. 2016).

Culturally-related beliefs, attitudes and practices toward cancer and treatment modalities, was the only community level barrier identified which adversely impacted on communities or individuals' non-acceptance of the radiotherapy and palliative care access improvement strategies on offer (Efsthathiou et al. 2016; Gafer & Elhaj 2014).

Table 2.2: Summary of the facilitators and barriers to implementation of cancer treatment and palliative care strategies in LMICs, 1990-2017

ICCCF levels	Facilitators	Barriers
Positive Policy Environment	- Prepared health professionals (Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Gafer & Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh & Hui 2015; Tapsfield & Bates 2011) - Financial support (Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Gafer & Elhaj 2014; Garcia-Gonzalez, Boulton & Epstein 2015; Herce et al. 2014; Kanavos, Vondoros & Garcia-Gonzalez 2009; Nwogu et al. 2016; Tapsfield & Bates 2011) - Political commitment (Agrawal et al. 2011; Ali 2016; Brown et al. 2017; Efstathiou et al. 2016; Herce et al. 2014; Krakauer et al. 2015) - Stakeholder engagement (Brown et al. 2017; Nwogu et al. 2016) (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015; Herce et al. 2014; Kanavos, Vondoros & Garcia-Gonzalez 2009; Krakauer et al. 2015; Tapsfield & Bates 2011) - Positive relationships with international organisations (Ali 2016; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014; Galalae et al. 2015; Krakauer et al. 2015; Nwogu et al. 2016) - Committed champions (Ali 2016; Banerjee 2009; Boit et al. 2014; Gafer & Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Nwogu et al. 2016) - Strategy aligned with national policy (Efstathiou et al. 2016)	- Lack of human resources (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014) - Financial constraints (Ali 2016; Nwogu et al. 2016) - Limited political commitment (Ali 2016; Nwogu et al. 2016) - Restrictive pharmacovigilance laws and regulations (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009) - Drug importation process challenges (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009)
Healthcare Organisation	- Supportive learning environment (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Gafer & Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh & Hui 2015; Tapsfield & Bates 2011) - Recognition of patients' needs (Banerjee 2009; Brown et al. 2017; Gafer & Elhaj 2014; Garcia-Gonzalez, Boulton & Epstein 2015; Herce et al. 2014)	- Limited physical infrastructure (Banerjee 2009; Efstathiou et al. 2016; Einck et al. 2014; Gafer & Elhaj 2014) - Prohibitive treatment costs (Einck et al. 2014; Nwogu et al. 2016)

	2014; Kanavos, Vondoros & Garcia-Gonzalez 2009; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh & Hui 2015; Wang et al. 2013) • Patient symptom management education (Banerjee 2009; Gafer & Elhaj 2014; Herce et al. 2014; Lal et al. 2015; Paiva et al. 2012; Shamieh & Hui 2015; Wang et al. 2013) • Strategy coordinator (Herce et al. 2014; Shamieh & Hui 2015; Tapsfield & Bates 2011) • Adherence to evidence-based practice (Einck et al. 2014; Galalae et al. 2015) • Strategy tailored to local resources and conditions (Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009) • Information management system (Brown et al. 2017; Nwogu et al. 2016) • Clearly defined strategy objectives (Agrawal et al. 2011; Brown et al. 2017; Galalae et al. 2015)	• Lack of WHO essential pain and palliative care medicines (Gafer & Elhaj 2014) • Fragmented health system (Efstathiou et al. 2016) • Irregular meeting attendance (Agrawal et al. 2011; Brown et al. 2017) • Limited or lack of radiotherapy equipment (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Nwogu et al. 2016) • Poor internet connectivity (Agrawal et al. 2011) (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009) • Radiotherapy equipment maintenance difficulties (Efstathiou et al. 2016) • Periodic radiotherapy equipment breakdown (Efstathiou et al. 2016) • Unstable electricity supply (Efstathiou et al. 2016) • Culturally related beliefs, attitudes and practices towards cancer and treatment modalities (Efstathiou et al. 2016; Gafer & Elhaj 2014)
Community	• Strong community networks (Boit et al. 2014; Herce et al. 2014) • Mobilisation and coordination of resources (Nwogu et al. 2016)	

Legend: ICCCF–Innovative Care for Chronic Conditions Framework; WHO–World Health Organisation

2.6 Discussion

Unfortunately, there is no high-level evidence to recommend any particular strategy to increase access to cancer treatment or palliative care in LMICs. Identified barriers and facilitators to implementing cancer treatment and palliative care improvement strategies in LMICs are scantily reported. Most improvement strategies have focused on increasing palliative care, and only four case studies have focused on radiotherapy services. Interestingly, none have focused on increasing access to surgical care, the mainstay of curative cancer care (Sullivan et al. 2015).

No strategies to date have been robustly evaluated or have included a health economic evaluation. Cancer treatment and palliative care services improvement strategies ought to be created with the inclusion of evaluation components to empirically ascertain whether goals have been achieved. Similarly, including evaluation components may provide data for design and implementation improvement in future cancer treatment and palliative care strategies in LMICs. Also, none of the strategies has made use of an implementation framework. Implementation framework can provide a helpful structure, overview or plan that describe the implementation process by grouping them into a set of concepts (Nilsen 2015). However, despite limitations in the quality of the studies, the literature yields valuable insights of relevance to policy-makers, financiers and researchers.

The included studies highlighted numerous facilitators and barriers affecting the successful implementation of cancer treatment and palliative care access improvement strategies at all three levels of the WHO's Innovative Care for Chronic Conditions Framework. These facilitators and barriers were complex and overlapping, concerned with: stakeholder engagement, financial support, a supportive learning environment, strong community networks, lack of human resources, financial constraints, and limited infrastructure. These findings confirm the complexity of implementing healthcare change, which requires an understanding of: processes of implementation; factors affecting implementation; the introduction of solutions, scale-up, and longer-term sustainability (Nilsen 2015; Peters et al. 2013). It is therefore justified to use a complex system lens to study, describe and understand strategies designed to improve access to cancer treatment and palliative care services in LMICs. Complexity arises from the: coexistence of implementation components that interact with each other; dynamics of implementation activity coordination; and cooperation of relevant stakeholders towards implementing improvement strategies (Brainard & Hunter 2016; Braithwaite et al. 2018; Churruca et al. 2019).

Financing, partnership, legislative frameworks, policy integration, leadership and advocacy, development and allocation of human resources are key requirements of a positive policy environment (WHO 2002a). This review has highlighted the importance of acquiring the necessary financial support before embarking on any access improvement strategy. Financing of cancer treatment and palliative care access improvement strategies determines who provides

funds, and who exercises influence over the funds. Cancer treatment and palliative care services across LMICs face a common challenge, which is high cost of cancer care. Financial pressures continue to undermine universal health coverage in most LMICs (Mathauer et al. 2016). It may be irrelevant to define a single best model of financing for cancer treatment and palliative care because of LMICs are dynamic. However, there are important principles that ought to guide LMICs progress in cancer treatment and palliative care service financing policy. For example, no country has attained universal cancer treatment and care coverage without strong political commitment from government, which is often reflected in national health budget. Government funding sources for cancer treatment and palliative care services ought to be diversified to include a combination of income tax, value-added tax, corporate tax and external funding sources to enable public subsidies to be captured by the poor (George 2016; Reeves et al. 2015).

International donors increasing their financing priority have been the key driving force for strengthening palliative care services in LMICs (Ali 2016; Boit et al. 2014; Gafer & Elhaj 2014; Herce et al. 2014; Tapsfield & Bates 2011), while locally based civil society organisations ability to established international ties is central to mobilising international funds for other cancer treatment initiatives (Nwogu et al. 2016). Donor funding approach for a specific purpose restricts strategy scope and limits the sponsor's ability to address unique local needs. This mismatch contributes to poor strategy acceptance at the local level. Donors ought to coordinate their efforts and align their priorities to the cancer treatment and palliative care service needs of LMICs to prevent financial fragmentation. While grant assistance from foreign donors is a critical financing source, it cannot be relied on to ensure long-term financial sustainability of cancer treatment and palliative care services in LMICs. LMICs ought to seek for opportunities for continuous long-term donor engagement to enable sustainability and scale-up of cancer treatment and palliative care services.

The private sector has a role to play in financing cancer treatment and palliative care services in LMICs. The review identified that the private sector's financial participation in the health sector in most LMICs has contributed significantly to the availability of radiotherapy (Efsthathiou et al. 2016), systemic anti-cancer therapies (Garcia-Gonzalez, Boulton & Epstein 2015; Kanavos, Vondoros & Garcia-Gonzalez 2009) and integrated cancer care (Nwogu et al. 2016). Providing policy and regulatory environment for engaging the private sector in LMICs could complement and augment governments' efforts to expanding cancer service delivery. However, it was identified that private sector financing approach in most LMICs exposes' patients without private health insurance and their families, who make up most of these populations, to extreme financial hardships making it impossible for them to pay or adhere to cancer treatment. As universal health coverage is yet to be fully realised in most LMICs (WHO and World Bank 2015), medical expenses related to cancer treatment continue to serve as a barrier to the successful improvement strategies implementation (Einck et al. 2014; Nwogu et al. 2016).

LMICs ought to institutionalise an appropriate financing system at the national level that offers appropriate financial incentives for providers and protects people living with cancer from financial hardships (WHO 2007).

Policies at the international, national, and regional levels are major issues in the successful implementation of cancer treatment and palliative care access improvement strategies. This review identified a paucity of evidence about policy development and implementation to improve access to cancer treatment and palliative care. Recently, WHO (2002a, 2002b) has assumed a more central position in providing supports for the policy development process in most LMICs, which is crucial to driving in-country reform. A cancer policy framework helps guide critical decisions and systematic course of actions by governments and other stakeholders, both of which are essential to improving cancer control (Adshead & Thorpe 2008). In LMICs, there remains a significant need for: credible policy agenda setting, realistic policy formulation; timely policy implementation; and periodic policy monitoring and evaluation using a theoretical framework (Exworthy 2008). Successful design and implementation of LMIC cancer control policies require high-quality health services research evidence, long-term commitment of resources, institutional capacity to enhance sustainability and reach of the policy, and co-designed approaches. While most of the cancer control policies developed in HICs offer useful starting points, LMIC policy-makers and supporting partners should consider the context, and power to obtain a full understanding of local policy process (Exworthy 2008).

The findings from this systematic review are consistent with other literature on the need to gain commitment and buy-in from relevant stakeholders, especially those in positions of authority and power (Ramaswamy & Gouillart 2010). Commitment from relevant stakeholders, such as political leaders, professional bodies, community leaders and civil society organisations is key to effective cancer treatment and palliative care improvement strategies. Commitment is difficult to achieve and sustain because it often involves convincing political leaders with evidence that cancer treatment and palliative care is important and ought to be accessible to people living with cancer. Also, to achieve and sustain commitment of stakeholders require meaningful engagement and connecting a cancer treatment purpose while avoiding conflicts (Norris et al. 2017). A participatory and co-design driven approach to implementation will assist in structuring health services to deliver effective, safe, and quality cancer treatment and palliative care. A participatory approach offers stakeholders: a more active and significant role in defining their priorities; diagnosing their challenges; securing funds; and implementing appropriate solutions for service improvement (Bate & Robert 2006).

As discussed in Chapter One, the WHO's Innovative Care for Chronic Conditions Framework employs a population health approach including: promoting continuity and coordination, encouraging quality through leadership and incentives, organising and equipping healthcare teams, using information systems, and supporting self-management and prevention (WHO 2002a). The performance of the health workforce drives health system improvement strategies

and determines how care is delivered. Developing and strengthening a country-based and country-led health workforce education initiative with appropriate international support is essential (Chen et al. 2004) if a responsive, fair, and efficient health outcome is to be realised. A country-based educational strategy helps reduce the outward migration of skilled health professionals from LMICs to HICs. An essential step towards achieving universal access to quality cancer treatment and palliative care is shifting human resource responsibilities and providing generalist doctors, nurses, allied health professionals, clinical pharmacists and community health workers with the necessary training, assessment tools, and essential medicines to deliver appropriate hospital and home-based care (Knaul et al. 2017; Knaul et al. 2011).

Implementation was largely affected by essential equipment challenges, particularly radiotherapy. Essential medical equipment, such as linear accelerators and high-dose-rate brachytherapy, are of paramount importance in cancer treatment and palliative care. Access to essential medical equipment provides the required assurance of quality, safety, efficacy, cost-effective, and scientific care delivery (WHO 2007). However, most LMICs: lack essential radiotherapy equipment; are faced with periodic radiotherapy equipment breakdowns; or have a poor radiotherapy equipment maintenance culture. Given that radiotherapy equipment is expensive to install, it is imperative to develop and implement specific preventive and corrective maintenance schedules, procedures and tasks to reduce unnecessary operational interruptions due to breakdowns. These challenges are part of broader medical equipment problems in most LMICs. Hence, to improve access to essential medical equipment, there is a need to develop simple, quality, and affordable medical technologies. By designing and engineering tools, and techniques less than 500 nanometers in size, the emerging field of nanotechnology offers a significant opportunity in overcoming different barriers to cancer treatment (Cuenca et al. 2006). Such technologies can help reduce the size, weight, shielding, and shipping costs of medical equipment. Moreover, technological advances can lead to a reduction of power consumption necessary for operating the equipment, and limited heat production. There should be greater emphasis on developing solar-powered equipment with high-quality insulation to limit the dependence on the national power grid (Atun et al. 2015).

The WHO's Innovative Care for Chronic Conditions Framework assigns significant emphasis on the community, acknowledging both the individuals living in a place and the place itself (WHO 2002a). Informed and prepared community resources help to promote awareness and reduce stigma, provide leadership and support, and deliver complementary services to ensure better outcomes for chronic care conditions (WHO 2002a). Recognising that community agencies, organisations, institutions, opinion leaders, and concern citizens are major stakeholders in strengthening cancer treatment and palliative care delivery will require promoting acceptance and understanding of the notion of community involvement in health and development (Kahssay & Oakley 1999). Community development literature may prove useful in designing and

implementing access improvement strategies. By definition, community development contributes to resource mobilisation, local empowerment, capacity development, and growth of political action through a network of relationships to help include the perspective and experience of grassroots (Helling, Serrano & Warren 2005).

2.6.1 Identified gaps

Investing and expanding cancer surgery, radiotherapy, systemic anti-cancer therapies and palliative care services ought to be an important priority for all LMICs. Well-established knowledge of the minimum standards for quality cancer surgery, radiotherapy, systemic anti-cancer therapies and palliative care services already exist and include: establishing or adopting national accreditation systems; scaling up cancer treatment and palliative care workforce; providing competency license; and aligning cancer treatment and palliative care service access with universal health coverage (Atun et al. 2015; Meara et al. 2015; Sullivan et al. 2015).

Another gap relates to the lack of incentives and rewards available for health professionals in LMICs. Incentives and rewards systems ought to be created for motivating health professionals. Both financial and non-financial incentives are essential to encourage health professionals to effectively perform, and engage in innovative clinical practice (WHO 2002a).

While there is an urgent need to increase the access to best evidence-based cancer care for people living in LMICs, this review highlights the importance of access to: universal health insurance, so that more people who need cancer treatment and palliative care can afford to access the care they need.

2.6.2 Moving forward

There are opportunities to draw valuable lessons from the experience in developing and implementing HIV/AIDS strategies in LMICs, as well as cancer treatment and palliative care strategies in HICs. Key among these lessons are: global mobilisation and investment funds; engagement of pharmaceutical companies; development of simple health technologies; strengthening health workforce capacity; development of a supportive national policy framework; connecting health system with community resources; and community participatory in strategy development (Khumalo-Sakutukwa et al. 2008; Knaul et al. 2011; Muthee et al. 2018; Narayan et al. 2011).

Recognising the importance of national policies in cancer control; dedicated financial budgets supporting cancer control; high level of advocacy and community involvement in strategy design; strong political support and acceptability of cancer control strategies; progress in cutting-edge technological advancements; and promoting high-quality cancer research and evidence-based treatment, are critical to taking cancer care in LMICs to the next stage of their

development (Knaul et al. 2011; Obeidat, Finnell & Lally 2011; Thompson, Cheetham & Baxi 2017).

Applying existing implementation research theories and frameworks to future strategy planning and implementation will assist in strengthening the work undertaken to improve access to cancer treatment and palliative care services in LMICs. Also, further research assessing LMICs' readiness to develop and implement cancer treatment and palliative care solutions is an important next step. A readiness assessment provides health planner and implementers with a preliminary understanding of the barriers and facilitators they are likely to encounter when implementing improvement strategies (Helfrich et al. 2009).

2.6.3 Strengths and limitations

Strengths of this review include its systematic methods and application of an internationally recognised framework. However, while the review distilled various facilitators and barriers to successful implementation from results reported in the studies, these had not been systematically or explicitly investigated using primary research techniques. Further caution is needed when interpreting the results because the methods used in the included studies contributed only low-level descriptive evidence, except for one randomised control trial (Wang et al. 2013).

2.6.4 Conclusions

While modest progress has been made to increase access to cancer treatment and palliative care in LMICs, major gaps still exist. In taking this work forward, LMICs are advised to adopt internationally recognised frameworks, such as the WHO's Innovative Care for Chronic Conditions Framework or the Health System Building Blocks Framework for Action intended to strengthen health systems to improve health outcomes to assist leaders to assess local population needs and integrate initiatives systematically, engage with the appropriate stakeholders and secure the necessary financial support (WHO 2007; WHO 2002a). It is essential to include an evaluation plan and budget during the development of the access improvement strategy. A need assessment and design evaluation should be undertaken by an independent evaluator to ensure that a reliable blind outcome-based analysis is generated.

2.7 Summary

The systematic review has identified the reported cancer treatment and palliative care access improvement strategies, as well as the facilitators and barriers to implementation in LMICs. To discover untapped knowledge in cancer surgery, systemic anti-cancer therapies and palliative care, the systematic review was not limited to radiotherapy service only; but rather had broad inclusion criteria.

Despite global efforts to improve access to radiotherapy services, there is a lack of high-quality data on the factors that influence the successful establishment of radiotherapy services in LMICs. Empirical research into radiotherapy services establishment in LMIC is scarce, with only four case report studies highlighting this subject. There is a need to further explore the perception of facilitators and barriers to establishing safe and sustainable radiotherapy services in LMICs.

The next Chapter will describe the mixed qualitative methods design employed in the ARC Project to develop a readiness self-assessment tool for radiotherapy service development in LMICs

2.8 References

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Chapter Three: Methods

3.1 Overview

Chapter One presented an overview of the two conceptual frameworks underpinning the ARC Project, namely the WHO's Innovative Care for Chronic Conditions Framework and Health System Building Blocks Framework for Action (WHO 2007; 2002). These internationally recognised WHO frameworks provide guidance about the building blocks for strengthening health systems at the micro, meso and macro levels and set the parameters for governments and health leaders to make improvement decisions (WHO 2007; 2002).

As reported in Chapter Two, the systematic review found little empirical evidence reporting barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. Yet, the establishment of safe and sustainable radiotherapy services is critical to improving cancer care outcomes in LMICs. However, establishing a safe and quality radiotherapy service is complex and major investment and requires considerable planning at the macro, meso and micro levels. Yet, few LMICs will have been involved in planning such a major, complex and very specialised health infrastructure project and there is currently little practical guidance available to identify the many different factors that need to be considered.

The IAEA has been assisting LMICs through the Technical Cooperation Programme and the Programme of Action for Cancer Therapy to conduct a need assessment, develop cancer control plan and mobilise the necessary resources to improve access to radiotherapy services (Enwerem-Bromson et al. 2015; Rosenblatt et al. 2012). Efforts have also been made to develop a tool to improve the way new technologies and treatment techniques are implemented into an existing radiotherapy centre in LMICs (Brown et al. 2014).

Despite these considerable efforts, it became clear through the systematic review (Study One) that the planning process leading to new radiotherapy service development in LMICs ideally needs to be informed by a more in-depth understanding of barriers and facilitators (Donkor et al. 2018). This Chapter details the methodological approaches used by the ARC Project's Study Two [Part A and Part B] to explore these barriers and develop practical guidance for LMICs.

3.2 Objectives

The objectives of the ARC Project were to:

1. identify and appraise the strategies that have been adopted to improve cancer care in LMICs;
2. identify and describe the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs;

3. develop a set of potential radiotherapy service development readiness requirements for use by LMICs establishing safe and sustainable radiotherapy services
4. seek feedback from the global radiotherapy experts' who contributed to Study Two [Part A] about the utility of the potential radiotherapy service development readiness assessment requirements for LMICs identified during the ARC Project's mid-point meta-inference; and
5. present the readiness self-assessment guide for use by LMICs to appraise their progress towards establishing safe and sustainable radiotherapy services through the end-point meta-inference of the ARC Project's integrated data.

3.3 Design

A pragmatic sequential mixed qualitative methods design was adopted for the ARC Project (Hennink, Hutter & Bailey 2020; Morse 2009; O'Reilly & Kiyimba 2015), which consisted of three discrete but linked studies, as detailed below.

- Study One: a systematic review (Donkor et al. 2018) (reported in Chapter Two). This systematic review provided insights about the strategies LMICs have employed to strengthen local cancer care;
- Study Two [Part A]: semi-structured interviews with global radiotherapy experts to enhance exploration and understanding of barriers and facilitators, and experiences of establishing radiotherapy services in LMICs (Donkor et al. 2020b); and
- Study Two [Part B]: a participant validation, aimed at confirming or refuting the requirements from a draft readiness self-assessment guide for radiotherapy service development, which was constructed through the integration of Study One and Two [Part A] data (Donkor et al. 2020a)

Table 3.1 shows the arrangement of the ARC Project's research questions, research methods and outputs, including three peer-reviewed manuscripts and 12 conferences.

Table 3.1: Overview of the ARC Project's research questions, methods and outputs

Research questions	Studies and methods	Objectives	Output
1. What efforts have been made to improve cancer care in LMICs and how effective have they been?	Study One: Systematic review	To identify and appraise the strategies that have been adopted to improve cancer care in LMICs	(Donkor et al. 2018)
2. What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?	- Study One: Systematic review - Study Two [Part A]: Semi-structured interviews with global radiotherapy experts	To identify and describe the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs	(Donkor et al. 2018) (Donkor et al. 2020b)
3. What readiness requirements do LMICs' need to consider when setting out to establish safe and sustainable radiotherapy services?	- Mid-point meta-inference - Study Two [Part B]: Participant validation with global radiotherapy experts - Data integration and end-point meta-inference	- To develop a set of potential radiotherapy service development readiness requirements for use by LMICs establishing safe and sustainable radiotherapy services - To seek feedback from the global radiotherapy experts' who contributed to Study Two [Part A] about the utility of the potential radiotherapy service development readiness assessment requirements for LMICs identified during the ARC Project's mid-point meta-inference - To present the readiness self-assessment guide for use by LMICs to appraise their progress towards establishing safe and sustainable radiotherapy services through the end-point meta-inference of the ARC Project's integrated data	(Donkor et al. 2020a)

3.3.1 Epistemological assumptions

The ARC Project used a pragmatic sequential mixed qualitative methods design. Epistemological assumptions are worldviews that underpin the interpretative frameworks selected by a researcher (Creswell & Poth 2018). Researchers take an epistemological stance when they decide to undertake qualitative research. The choice of an epistemological assumption is critical because it enables transparency and influences the selection of the interpretative framework, as well as the research process (Creswell & Poth 2018). The most frequently used epistemological assumptions by qualitative researchers are post-positivism, constructivism, participatory and pragmatism (Creswell & Poth 2018).

Post-positivism was considered a poor fit for the ARC Project because post-positivism incorporates elements of logical cause and effect as well as deterministic based on a priori theories (Creswell & Poth 2018). Similarly, constructivism was also deemed to be unsuitable because it assumes reality is subjectively constructed (Creswell & Poth 2018). However, the ARC Project assumes that there is an objective reality to whether radiotherapy services succeed or fail.

The epistemological assumptions inherent in pragmatism were deemed to be the best fit for the ARC Project. Primarily, because pragmatism is a credible research ideology that does not align itself with a single reality or philosophy. It is a valuable approach to solving complex real-world problems (Morgan 2013) and seeks to clarify meanings of intellectual concepts by tracking conceivable practical outcomes (Cherryholmes 1992). As a result, pragmatism has become popular in social and health services research, particularly in planning, developing, implementing and evaluating health programmes (Maxcy 2010).

A pragmatist approach considers the research question and its intended purpose to be more important than either the method used or the worldview that underpins the method (Creswell & Poth 2018; Michael 2002). Pragmatism provides the opportunity to use multiple methods, assumptions, different forms of data collection and analysis (Creswell & Poth 2018). Thus, pragmatic philosophy rejects the postpositive and the constructivist paradigms, which enabled the ARC Project doctoral research to study readiness to establish safe and sustainable radiotherapy services in LMICs as an area of interest while adopting methods that are appropriate and applying the findings in a positive manner in agreement with their values (Creswell & Poth 2018). For these reasons, it can be argued that the symbolic experience of the researcher and the ability to identify what is considered important makes pragmatism philosophy worthy of consideration to explore a practical topic in radiotherapy service development in LMICs.

Pragmatism also enabled the researcher to combine multiple qualitative methods through systematic collection, ordering, description, interpretation and integration of textual data

generated from observation, interviews and documentation (Creswell & Poth 2018; Malterud 2001). A pragmatic qualitative researcher focuses on the consequences and select methods based on the goals of the research rather than the epistemological concerns (Patton 2014). In a pragmatic approach to qualitative methods, the goal could be to explore the behaviour, processes of interaction and better understand meanings, values and experiences of sampled individuals or groups in their natural context (Creswell & Creswell 2017; Kitto, Chesters & Grbich 2008).

The application of pragmatism as a philosophical assumption in qualitative research is still in its early stages, but provides an essential approach for making decisions that are practical and contextually responsive (Patton 2014). Contextually responsive involves understanding the demands, constraints and opportunities available within the context in which the research is taking place. There are variations in how a qualitative research might be designed and what the intent of the research might be because of the underlying assumptions, but pragmatic qualitative researchers move comfortably within and among various assumptions (Merriam & Tisdell 2015; Patton 2014). Pragmatically, qualitative research may be conducted because an issue needs to be explored to: gain deeper understanding of the complexity of the problem; empower individuals to share their stories; develop theory to explain and address gaps in knowledge; and gain better understanding of the contexts in which participants in a study address a problem (Creswell & Poth 2018; O'Cathain 2018; Patton 2014).

Pragmatism recognises that different qualitative approaches will suit different purposes. Pragmatic qualitative researchers can apply principles from qualitative approaches such as: narrative; ethnography; case study; grounded theory; and phenomenological research to better understand a complex concept (Creswell & Poth 2018).

The section below describes why case study, narrative research, phenomenological research, ethnographic research and, in its pure sense, grounded theory were not considered suitable for the ARC Project. Instead, it explains that an integrated approach best suited the pragmatically influenced design of the ARC Project.

Case study

Case study research is an empirical method that investigates one or more cases within a real-world context over time, through detailed, in-depth data collection and reports the explanatory and not just the descriptive or exploratory of the case (Yin 2018). A case can be limited to a characteristic, behaviour or trait. A case can also be limited to a situation that provides the researcher and the audience of the report with the felt shared experience of the participants located in a particular place and time (Baker & Charvat 2008; Lichtman 2012; Yin 2018). A case study approach was not deemed to be a good fit for the ARC Project because of the limitations

in inferring generalisable principles about radiotherapy service development readiness in LMICs from the study of a very small number of examples.

Phenomenological research

Phenomenology is a qualitative approach focused on the study of lived experience (Moran & Mooney 2002). Phenomenology aims to uncover the deeper meaning of latent concepts (Moran & Mooney 2002). Also, phenomenology enables the researcher to understand both the person's experiences and the meaning of the experience (Chesnay 2014). For example, phenomenology asks: what is the nature, meaning, significance, uniqueness or singularity of this experience as individuals live through it? (van Manen 2016). Phenomenology was deemed a poor fit for the ARC Project because the subject of study was considered to be barriers and facilitators to radiotherapy establishment rather than experiential phenomena. While the ARC Project was obliged to access information about these barriers/facilitators indirectly through the experience of people involved rather than more directly through an ethnographic approach (see below), experience was assumed to be a conduit, rather than the phenomenon under investigation itself. As such, participants were asked to substantiate any learning they extrapolated from experience by explaining how these arose from specific circumstances of radiotherapy establishment rather than to focus on any personal meaning they derived (Offredy & Vickers 2013).

Narrative research

In narrative research, the goal is to capture the detailed stories or lived experiences of a single life or lives of a small number of individuals (Creswell & Poth 2018; Polkinghorne 2010). The meaning of the individual experiences is chronologically ordered to provide a certain pattern of coherence (Creswell & Poth 2018). For instance, a non-chronologically ordered narrative may allow the researcher to complicate the perspective from which the story is told (Baker 2018).

Stories are the primary way to render human experience meaningful (Polkinghorne 2010). Narrative research plays an important role in health care. In health, narrative research has been used to investigate several topics, including patients' experiences of eating disorder to understand the social, psychological, economic and cultural conditions (Patching & Lawler 2009). Thus, narratives provide insights into the patients' world of illness that can help shape healthcare professional-patient communication (Lucius-Hoene, Holmberg & Meyer 2018). There are several approaches that can be adopted in narrative research, which impact the way that data are collected and analysed. Forms of narrative research include biographical study, autobiography, life story and oral story (Creswell & Poth 2018).

A narrative approach did not align well the ARC Project because the barriers and facilitators to radiotherapy service establishment in LMICs inquiry starting point was in the theoretical understandings that allowed the researcher to create semi-structured interview topic guide.

Narrative research often ignores broader structural influences (Walker 2001); however, the ARC Project was interested in broad pertinent data from people involved in establishing radiotherapy services as a means to contextualise their accounts of barriers and facilitators to radiotherapy service establishment in LMICs at the macros, meso and micro levels. Also, collecting narrative about the day-to-day experiences influencing an individual's involvement in radiotherapy service establishment in LMICs was not feasible. As a result, the ARC Project asked people involved in establishing radiotherapy services in LMICs to provide information about what radiotherapy service project activities they were engaged in, the timeframe for that radiotherapy service project, significant experiences and why they were significant as well as challenges they encountered and how they were addressed.

Ethnographic research

Ethnography is enshrined as a: method; theoretical orientation; and philosophical paradigm (Tedlock 2000). The focus of ethnography as a qualitative research approach is to understand human society and culture (Creswell & Poth 2018; Tedlock 2000). Hence, ethnography is mostly used in the field of social anthropology, such as studying children and childhood in different socio-cultural contexts to understand factors that actively shape child development (Mukherji & Albon 2018). Ethnographic research methods are sometimes called field research, observational research or participant observation (Allen 2010; Holloway 2005). Ethnographers enter the field with a plan but allow discovered realities to modify the questions and approaches been used (Padgett 2016).

Principles of ethnography were not adopted in the ARC Project because ethnography as a qualitative research emphasises the direct contact and observation of the participant in the natural context to document beliefs and practices from participant's own point of view (Lapan, Quartaroli & Riemer 2011; Patton 2014). During the timeframe of the ARC Project, it was not feasible for the researcher to travel to multiple LMICs to observe and engage informants to learn about the factors that influenced the development of their radiotherapy services. Due to the time demand, ethnography is less frequently used compared to other qualitative approaches (Padgett 2016). As noted above, an in-depth investigation of one or two case studies was not considered likely to yield generalisable principles for informing a self-assessment readiness guide for LMICs establishing safe and sustainable radiotherapy services. Instead, it was considered more useful to access information across a larger number of LMICs less directly through the experience of people involved, provided this was done in a rigorous way (see below).

Grounded theory

Grounded theory is used frequently in health, humanities and social sciences to generate theory that is grounded in empirical data (Glaser & Strauss 2017); hence the name 'grounded theory'

(Olshansky 2014b). Grounded theory emerged to challenge the notion that qualitative research could produce only description and did not have the ability to build theory (Bryant & Charmaz 2019).

The grounded theory approach consists of a systematic, yet flexible guidelines for data collection and analysis, with a focus to develop theory (Charmaz 2006). Data in grounded theory consist of qualitative information, usually in the form of transcripts from interviews with participants, documents or ethnographic data (Olshansky 2014a; Padgett 2016). Grounded theory places importance on empirical scrutiny and analytic precision to contribute to knowledge that can inform practices and policies that researchers seek to change (Charmaz 2011). The analytical process of grounded theory approach consists of coding data; developing, checking and integrating conceptual categories; and writing analytic narratives throughout the inquiry (Bryant & Charmaz 2007).

Grounded theory is a building process that happens through the rigorous application of constant comparative approach and theoretical sampling for saturation (Browne 2004). The purpose of constant comparison is to see if the data support and continue to support emerging concepts (Holton & Walsh 2016). This means that grounded theory takes an 'inductive' approach to analysis – that is it starts with a 'blank page' in terms of theory but then develops a theory based on the empirical data collected. This contrasts with a 'deductive' approach, in which the researcher applies a pre-existing theory to the data to deepen interpretation (Bradley, Curry & Devers 2007).

Since the inception of grounded theory, its basic methods – especially constant comparison and the notion of data saturation – have been adopted by other qualitative methodologies, including integrated methods that combine inductive and deductive approaches in accordance with a pragmatic philosophy of what will best serve the practical aims of the study (Bradley, Curry & Devers 2007). The ARC Project took a pragmatic integrative approach to grounded theory to ensure that interpretation built on previous relevant work as well as remain open to any new insights shared by informants that could further develop the field (Bradley, Curry & Devers 2007).

3.3.2 Contextualising a mixed qualitative methods design

Mixed methods design is recognised as the third research paradigm, which involves combining multiple methods of data collection and analysis, integrating the findings and drawing inferences using both qualitative and quantitative approaches in a single study to get a better understanding of the research problem (Creswell & Clark 2018). The goal of mixed methods is to draw upon the strengths and minimise any limitations of qualitative and quantitative approaches (Johnson & Onwuegbuzie 2004). Several terms have been used interchangeably within research communities to describe mixed method studies, namely: multi-methods; multiple

methods; multi-phase design; and hybrid design (O'Cathain 2013; Schoonenboom & Johnson 2017; Teddlie & Tashakkori 2009).

The term mixed methods research design usually refers to the application of qualitative and quantitative methods (Almeida 2018; Teddlie & Tashakkori 2009). The field of mixed methods research has been struggling since its inception with how to define its approach. Consequently, the field of mixed methods research includes a landscape of definitions that have introduced confusion and controversy (Clark & Ivankova 2016; Creswell & Clark 2017). The confusion surrounding the meaning of mixed methods has hindered the consolidation of standards for the: assessment of the methodological quality of mixed methods studies; and reporting of primary mixed methods studies (Anguera et al. 2018). It has been argued that the accurate and consistent use of methodological terminology is needed to strengthen the rigour of mixed methods research (Anguera et al. 2018). With this in mind, attempts have been made to define mixed methods research, with the most recent definition stating that:

Mixed methods research is a design where researchers combine several research methods, either across paradigms (an example is quantitative-qualitative methods) or within the interpretative paradigm (an example is the mixing qualitative methods) (Hennink, Hutter & Bailey 2020, p. 42).

This definition acknowledged the value of the integration of purely qualitative or quantitative data into a single study, which has also been referred to as: monomethod design, single-phased design, multiple methods design, combined qualitative methodology, qualitative mixed method designs and qualitatively-driven mixed-method (Morse 2010, 2015; Teddlie & Tashakkori 2009). Given the lack of an internationally agreed definition over nomenclature in the field of mixed methods research and the need for clarity, the ARC Project has adopted the term mixed qualitative methods design. In the ARC Project, mixed qualitative methods design pertains to a qualitative research approach using more than one data collection method (Hennink, Hutter & Bailey 2020).

3.3.3 Applying mixed qualitative methods design

A mixed qualitative methods design has a broad appeal in health services research because it has the ability to integrate different qualitative methods to support strengths and overcome weaknesses of individual methods (Morse 2009; Tashakkori & Teddlie 2003). A mixed qualitative methods design generates meaning and can bring about change. This can be achieved by working systematically through research problems to find answers and to cause change activity in the light of identified answers (Taylor 2013).

To address the research questions, the ARC Project sought to identify and better understand the perceived facilitators and barriers to establishing safe and sustainable radiotherapy services in LMICs based on global radiotherapy experts' perception (exploratory qualitative data) and a

draft set of requirements to be used to appraise LMICs' preparedness to establish new radiotherapy services (participant validation, confirmatory qualitative data). The overall aim of the ARC Project was addressed through data integration and meta-inference.

3.3.4 Benefits of mixed qualitative methods design

There has been a push towards integrating qualitative methods in what is now called mixed qualitative methods research design (Hennink, Hutter & Bailey 2020; Morse 2009; O'Reilly & Kiyimba 2015). Mixed qualitative methods research design is well situated in global health, even though their applications have not been thoroughly discussed in the academic literature. In this context, mixed qualitative methods research design is vital because it helps understand the motivations and constraints under which policy- and decision-makers operate and develop solutions that are context specific (Singh, Krishan & Telford 2019). A mixed qualitative methods research design helps understand how stakeholders interpret, experience and accept health interventions. Similarly, quality indicators can be developed through mixed qualitative methods research designs to track the impact of a new or existing policy (Hennink, Hutter & Bailey 2020; Singh, Krishan & Telford 2019).

But despite the potential of mixed qualitative method design, there has been little work done to consider the implications of combining multiple qualitative research methods (O'Reilly & Kiyimba 2015). Most mixed qualitative methods studies are not published as mixed methods articles, with most researchers publishing the core qualitative component of the study as a standalone manuscript and the supplementary qualitative component in another. Most journals have rigid page limit requirements, which is a major contributing factor why researchers publish different components of a mixed methods study separately (DeCuir-Gunby & Schutz 2016).

3.3.5 Rationale for mixed qualitative methods in the ARC Project

In qualitative research, different methodological approaches are available that can be pragmatically mixed or combined to study a complex phenomenon (i.e. crisis experience) (Flick 2011). The mixing of qualitative methods provides a better and more complete picture of a situation than a single qualitative method alone and thus contribute to promoting quality in research (Hennink, Hutter & Bailey 2020).

Expanding access to radiotherapy services is a global priority (Abdel-Wahab, Fidarova & Polo 2017). Establishing safe and sustainable radiotherapy services in LMICs faces many issues of political buy-in, workforce training and education, equipment maintenance and misaligned incentives. Therefore, responding to the priority of establishing safe and sustainable radiotherapy services in LMICs could benefit from mixed qualitative methods research because it could facilitate a deeper understanding of the complexity from the perspectives and experiences of individuals involved in expanding access to radiotherapy services in LMICs.

3.3.6 Consideration for a sequential mixed qualitative methods design

In the ARC Project, sequentially mixing of qualitative methods occurred through the findings of Study One (systematic review) being used to inform the design of the semi-structured interviews (Study Two [Part A]) and subsequently using the findings to guide the design and/or analysis of the participant validation (Study Two [Part B]).

A sequential mixed qualitative methods design made it possible to obtain different perspectives on the same phenomena and ultimately would help confirm, explain, enhance, provide new insight or contradict the ARC Project findings (Morse & Cheek 2014; Morse & Niehaus 2016). Sequential mixed qualitative methods design, if conducted with deliberate care, has the capacity to allow a better understanding of a broader set of topics from various perspectives and experiences (Morse & Niehaus 2016).

A sequential mixed qualitative method design was selected as it was the design most likely to enable the ARC Project to explore the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs from the perspectives of global radiotherapy experts, and provide additional new insights into maintaining radiotherapy services in less resource settings. The sub-questions that could not be answered with the semi-structured interviews (Study Two [Part A]) were answered with the participant validation (Study Two [Part B]), which propelled the project data integration and meta-inference that led to the development of a readiness self-assessment guide for LMICs establishing safe and sustainable radiotherapy services (refer to Figure 3.1).

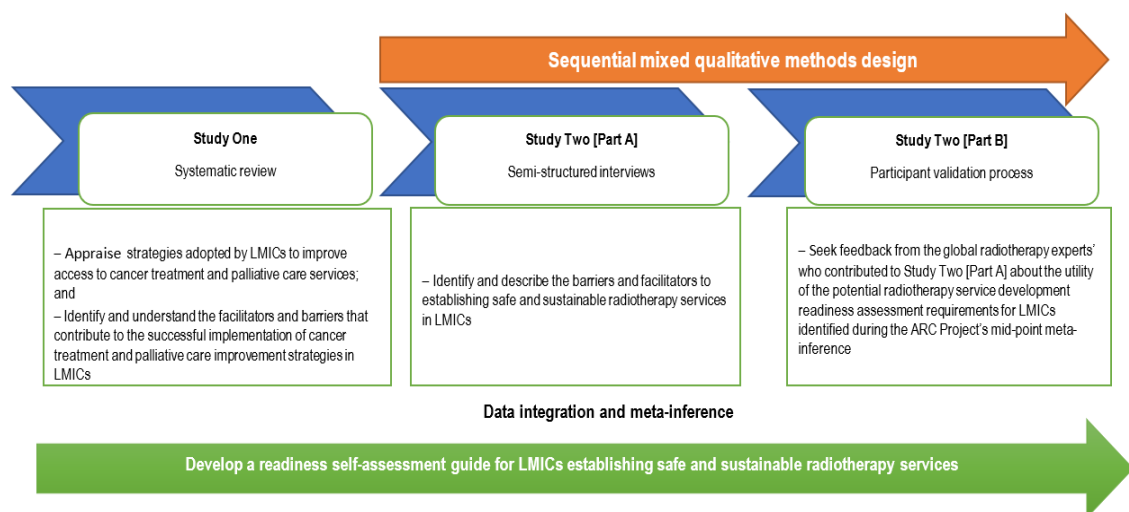


Figure 3.1: Alignment of the sequential mixed qualitative methods design of the ARC Project

Summary

Having described the justification for adopting a sequential mixed qualitative methods design, the next section will describe the ARC Project's Study Two [Part A and Part B] methods including the: participants, settings, recruitment strategies, how data were collected and analysed and the various ethical considerations.

3.4 Semi-structured interviews (Study Two [Part A])

The section below describes the process of interviewing global radiotherapy experts.

3.4.1 Participants and settings

Clinical/radiation oncologists, medical physicists, radiation therapists and administrators primarily involved in establishing safe and sustainable radiotherapy services or providing radiotherapy to cancer patients in LMICs were all eligible to participate in Study Two [Part A] if they had: been actively involved in establishing or strengthening radiotherapy services and/or delivering radiotherapy in an LMIC for at least two years; and spoke English. Individuals such as: those who were involved with only HICs' radiotherapy service improvements; had limited or no knowledge and information about the radiotherapy initiative; and were unable to communicate in English were excluded.

3.4.2 Recruitment of participants

A purposive sample using a snowball recruitment strategy was adopted to maximise the recruitment of participants with different experiences in terms of the LMICs where they had worked as volunteers or in a paid capacity, their roles, age and gender. Purposive and snowball sampling strategies are commonly used in qualitative research to identify participants with in-depth knowledge and/or experience with the phenomenon of interest (Bailey 2008).

Recruitment of participants for the interviews was facilitated by three of the researchers (AD, SA and JP). To commence recruitment, a potential participants' matrix was created. Potential participants were identified authors featured in the systematic review, reports from international organisations on access to radiotherapy services, along with recommendations and personal and professional social networks, and then screened for eligibility. Initial contact with potential participants was made via electronic mail by AD or through JP and SA (refer to Appendix E for invitational email). Interested potential participants contacted AD who provided additional written study information and identified date and time for the interview. Participants were assured that names and other identifying information would be removed from the transcripts (refer to Appendix F for participant information sheet). The number of participants recruited was determined by data saturation. Between September 2018 and March 2019, a total of 41 email invitations were sent to a global pool of potential participants.

3.4.3 Data collection

A series of semi-structured interviews were used as a data collection strategy to identify and better understand the perceived barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. A semi-structured interview is a widely used method for data collection in both qualitative and mixed methods studies (Creswell & Clark 2018; McIntosh & Morse 2015). Semi-structured interviews are designed to elicit ideas and opinions on a subject of interest by offering topics and questions to participants. It is typically important to carefully avoid imposing preconceived meaning from one participant's interview on the next (Galletta 2013).

Prior to the interview commencement, all participants provided oral consent and permission to audio-record using inbuilt functional hardware of the Voice over Internet Protocol. A smartphone was also used to record the interview as a secondary backup, which was immediately transferred onto a password-protected university computer and deleted from the smartphone afterwards. Detailed interview notes were also taken. All interviews were conducted via telephone in English from the University of Technology Sydney campus in Ultimo, Australia. Seven of the interviews were co-facilitated by either TL/JP and the rest were conducted by AD. The data collection took place between August 2018 and March 2019.

An interview guide informed by the literature (Donkor et al. 2018) and WHO's Innovative Care for Chronic Conditions Framework was used (refer to Table 3.2 for the interview guide). A series of open questions form the basis of the interview guide, which allowed for follow-up, probing and opportunity to elicit unanticipated information. The interview guide was developed by the research team and pre-tested with one international radiotherapy expert from Australia to ensure the questions made sense and supported the study's aim and research question. The data from the pre-test interview was removed from the final analysis. The question routes were iterative because the ARC Project was more concerned with the processes that led to the success or failure of a radiotherapy service initiative rather than the outcome. As a result, the research questions took the form of "what" and "how" to capture the experiences and perspectives of participants (Agee 2009). These forms of research questions also enabled the deconstruction of radiotherapy service establishment processes into component parts.

A summary of the major issues highlighted during each interview was emailed to each participant to ensure the information reflected the interview content. The researcher (AD) noted any question or idea for a follow-up after each interview. The qualitative data collection continued until no new insights emerged and the data was considered to be saturated.

Table 3.2: Semi-structured interview topic guide

• Can you tell me about a project you were involved with, which aim was to establish, strengthen and/or improve access to radiotherapy services in LMICs? — Question prompts: location/setting; year initiated; project activities; and financier. • What factors in your view made it easy/difficult to design, plan, execute and sustain that radiotherapy service? Question prompts: — how did positive policy environment influence the process of establishing the new radiotherapy service (taking into consideration partnership, policies, financing, legislative framework, leadership and advocacy and human resource)? — How did the healthcare organisation influence the process of establishing the new radiotherapy service (taking into consideration continuity and coordination, leadership and incentives, organisation and equipment, information systems and social support)? — How did community influence the process of establishing the new radiotherapy service (taking into consideration awareness, community leadership and support, resource mobilisation and coordination and complementary services)? • Can you tell me what you would do differently next time, if you were to design, plan, execute or implement a new radiotherapy service in an LMIC? • Are there other people, particularly those “on the ground” in the LMIC that I need to speak to about this project?
--

3.4.4 Data analysis

There are different ways to analyse semi-structured interviews. Both inductive and deductive approaches were used to analyse the data from the semi-structured interviews (Bradley, Curry & Devers 2007; Elo & Kyngäs 2008). All recorded interviews were transcribed verbatim by an online audio transcription service. Transcripts were imported into NVivo 12 for data management, organisation and coding. Data collection and analysis occurred simultaneously. As the purpose of the ARC Project was to explore the experiences, perceptions and better understand the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, the initial step to developing codes was purely inductive before applying an organising framework for the codes (Bradley, Curry & Devers 2007).

Inductive analysis began with the researcher (AD) closely listening to each audio recording multiple times and reading and re-reading the transcripts line-by-line to get an understanding of how the information applied to the establishment and sustainability of radiotherapy services in LMICs. This approach to analysis was adopted to avoid misinterpreting the data (Burnard 1991; Gale et al. 2013). Development of the code structure was achieved by taking the data apart and defining how it was constituted through an iterative, comparative and interactive approach

(Charmaz 2011). Thus, the researcher actively engaged the data by reviewing it in detail and as a concept became evident, a code was assigned.

Also, during the data analysis, the researcher compared text segments-to-segments that have been previously assigned the same code and decided whether they reflected the same concept (Bradley, Curry & Devers 2007; Browne 2004). The researcher remained open to new themes and multiple meanings within the texts without a pre-specified framework. Once a code was identified in the text, it was reused to capture new ideas in the text. Coded texts were grouped into categories reflecting the barriers and facilitators and they were discussed in a bi-weekly team meeting. Inductive approach was chosen as the initial step to define code structure because it was important that the findings were useful to LMICs.

Deductive analysis began by applying the WHO's Innovative Care for Chronic Conditions Framework and the Health System Building Blocks Framework for Action to provide a structured matrix, which allowed a systematic approach to data analysis (Elo & Kyngäs 2008). All data with identified codes and modified with the addition of new emergent ideas after the line-by-line reading by one researcher (AD) were indexed. The final coded results and categories with the transcripts were presented in a table and verified by the research team. Categories were synthesised into themes and reviewed via regular discussions. To identify areas of convergence and discrepancy among participants, a constant comparison of themes was conducted. Participants' quotations from the interview were selected to illustrate the themes. Demographic data such as age, gender, role characteristics, years of professional experience, and geographical location were analysed using descriptive statistics. To enhance trustworthiness, emerging themes were shared with selected participants and participants were provided with an opportunity to provide feedback or to clarify a point.

The findings of the semi-structured interviews are reported in Chapter Four. The sections below detail the processes undertaken in collecting and analysing data to complete the participant validation (Study Two [Part B]).

3.5 Participant validation process (Study Two [Part B])

A participant validation process is recognised as an essential technique for enabling researchers to refine their data interpretations and enhance credibility (Birt et al. 2016). Once the semi-structured interviews (Study Two [Part A]) were completed, the participant validation component was initiated to generate, confirm, refute or enhance the readiness requirements, identified through the mid-point meta-inference, which integrated the data from the Study One and Study Two [Part A].

3.5.1 Participants and setting

All the participants (clinical/radiation oncologists, medical physicists, radiation therapists and administrators) that were interviewed during Study Two [Part A] data collection were eligible and invited to participate in the validation process (Study Two [Part B]).

3.5.2 Recruitment of participants

All global radiotherapy experts who participated in the semi-structured interviews (Study Two [Part A]) were eligible to participate in Study Two [Part B]. The literature is varied regarding the number of experts required to review and confirm generated requirements that should form the content of a guide (Abell, Springer & Kamata 2009). Sample size decisions are mostly based on the length and complexity of the guide (Abell, Springer & Kamata 2009). Nevertheless, some studies have recommended a range between six to 20 experts to help generate more information about the guide (Abell, Springer & Kamata 2009; Rubio et al. 2003).

Participants were contacted by only AD via electronic mail and provided with an instruction sheet and conceptual definition of each readiness domain (refer to Appendix G for invitational email). Participants were assured that names and key identifying information will be removed so that there was no direct link between the participant's identity and the information provided. The participants were provided with an opportunity to confirm or refute the listed readiness requirements and asked to check for missing concepts, identifying redundant requirements and/or suggest grammatical improvement to ensure that the intent of the requirement was clear and relevant.

3.5.3 Data collection

A series of steps were used as a data collection strategy, which included: readiness requirement generation; readiness requirement confirmation; and readiness requirement revision (refer to Figure 3.2). Data collection for this Study took place between July 2019 and October 2019. The sections below detail the steps undertaken in completing the participant validation process.

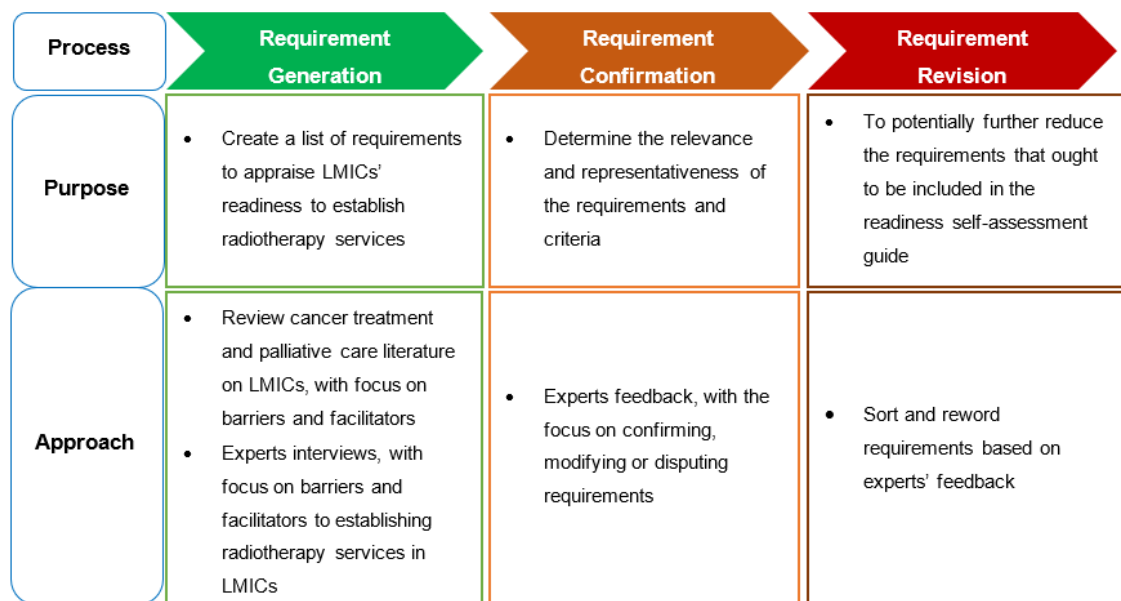


Figure 3.2: Graphical representation of the processes leading to the participant validation

Step One: Initial generation of the readiness requirements

The First Step was to turn the identified data on the establishment of safe and sustainable radiotherapy services in LMICs from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]) into readiness requirements (Donkor et al. 2018; Donkor et al. 2020b). Through an iterative process, the research team accurately defined and delineated the relevant domains of the readiness construct to prevent construct underrepresentation as well as avoid extraneous factors. Clear interpretation and boundaries of each domain of the readiness construct to be assessed made it possible to map the various requirement with criterion to the domains.

A sufficiently large pool of readiness requirements were drawn from the systematic review and semi-structured interviews and compiled into an Excel spreadsheet to assess the readiness domains. Care was taken to ensure that each readiness domain has an adequate sampling of requirements. Again, the systematic review and semi-structured interviews with global radiotherapy experts provided great insights into the requirement wording. The research team (AD, TL, SA and JP) considered issues, such as: wording clarity; negative and positive worded requirements; and wording redundancy through an iterative editing, review and proofreading of the initial generated requirements. To ensure easy reading, generated requirements were kept short, simple and free of jargon. Also, statements that address two issues were avoided.

Step Two: Experts confirmation of the readiness requirements

The Second Step was designed to allow the global radiotherapy experts to cross-check and confirm or refute whether the requirements generated were appropriate and relevant to

qualitatively assess readiness to establish a new radiotherapy service. This step helped establish generated requirements relevance and representativeness of the readiness self-assessment guide for LMICs establishing safe and sustainable radiotherapy services (Bolarinwa 2015; Burton & Mazerolle 2011; Hardesty & Bearden 2004).

Consensus implied general agreement, though not necessarily unanimity (Kea & Sun 2015). The process of reaching consensus also meant that each radiotherapy expert was given the equal opportunity to correct errors, challenge or confirm accurate interpretations and influence the final decision on readiness requirements (Doyle 2007; Madill & Sullivan 2018).

For the tasks, global radiotherapy experts were asked if they agree with the readiness requirements by addressing the following statements:

- if you think any of the requirements already listed under the readiness domains should be removed, please place “R” as “Remove” in the inclusion column;
- if you think any of the requirements already listed under the readiness domains should be included but needs to be revised or modified in some way, please “M” as “Modify” in the inclusion column; and
- if you think any of the requirements already listed under the readiness domains should be included without changes, please place “A” as “Accept” in the inclusion column.

In addition, global radiotherapy experts had an option for a ‘no idea’. To evaluate the comprehensiveness of each readiness domain, experts were also asked to recommend other readiness requirements that might have been omitted from the list, readiness requirements that should be deleted because they are not consistent with the domain and/or readiness requirements that should be combined. This approach is consistent with the literature on guide development (Gagnon et al. 2018; Grant & Davis 1997).

Each global radiotherapy expert was given two weeks to complete the survey. A follow-up email remainder prompting potential participants about the deadline to complete the survey was sent (refer to Appendix H for follow-up email). If there was no response, it was considered a decline to participate. Participants completing and submitting the survey was considered as consent to cover all aspects of participation and use of the collected data.

Step Three: Produce the final draft of the readiness self-assessment guide

At the conclusion of Study Two [Part B], a final set of readiness requirements was created by consolidating some original readiness requirements and making amendments to the wording of several other requirements.

An iterative approach to achieving agreement

The central feature of the ARC Project wasn't about achieving consensus on readiness requirements. However, variety of well-known approaches were applied to gain some degree of agreement. The agreement approaches included:

- **discussion of readiness requirements among research team** – the readiness requirements were discussed with the goal of identifying opinions and information on the readiness topic. The general mechanism for improving each readiness requirements was often identified during the discussion meeting;
- **expert review** – each member of the global radiotherapy experts who contributed to generating the readiness requirements were given the opportunity to actively state whether they agree or disagree with the requirements. The number of agreements was counted to determine if consensus threshold was satisfied; and
- **identifying and addressing concerns** – experts were asked to share their concerns on readiness requirements with the disagreement so that any potential errors can be addressed. Several rounds of discussions were held with the research team to address or clarify the concern experts outlined. The discussion involved active listening and sharing information. Multiple concerns and information were shared until a satisfactory decision passed the consent threshold for the research team.

3.6 Data analysis

Participants' responses using 'R' for 'Remove', 'M' for 'Modify' and 'A' for 'Accept' did not have numerical value but were treated as opinions intended to elicit additional qualitative comments; hence, median score and interquartile range were not calculated (Birt et al. 2016). Qualitative comments from participants were imported into NVivo-12 for management, organisation and coding. Texts that were of interest to the analysis were systematically distinguished and comments from participants were read and re-read at several levels of word, sentence, paragraphs and whole to gain an understanding of the meaning.

Texts that were of interest to the analysis were systematically distinguished and comments from participants were read and re-read at several levels of word, sentence, paragraphs and whole to gain an understanding of the meaning. The researcher remained open to understanding the new, deleted or combined readiness requirements recommended by the participants without a pre-specified framework.

Coded texts were grouped into categories reflecting readiness requirements. Areas of convergence and discrepancy among participants were identified through constant comparison, a qualitative data-analytic procedure whereby each finding and interpretation is compared with existing findings emerging from the data analysis (Boeije 2002). Regular feedback meetings

were held with a senior researcher (TL) to share comments from participants, discuss and validate the refined readiness requirements. Feedback is a common iterative consensus approach for supporting validity or trustworthiness by reflecting on the data (Heritage 2016).

3.7 Data integration and meta-inferences

Integration is the process of bringing data from multiple research methods together to access knowledge or insights unavailable to a single methodological technique (Moseholm & Fetters 2017). The purpose of the integration in the ARC Project was to connect the systematic review (Study One) and semi-structured interview (Study Two [Part A]) data to provide a better understanding of the barriers and facilitators to establishing radiotherapy services in LMICs, which resulted in the generation of readiness requirements. Finally, data integration of all the studies within the ARC Project was undertaken to answer the mixed qualitative methods research question.

There are diverse approaches that can be used to integrate mixed methods research procedures and data. In the ARC Project, data integration was implemented at the design, methods, interpretation and reporting levels of the ARC Project (Fetters, Curry & Creswell 2013). Figure 3.3 outlines the various studies, procedures and related products of the ARC Project. A radiotherapy service development self-assessment readiness guide designed to assist LMICs planning to establish safe and sustainable radiotherapy services was the end deliverable of the ARC Project.

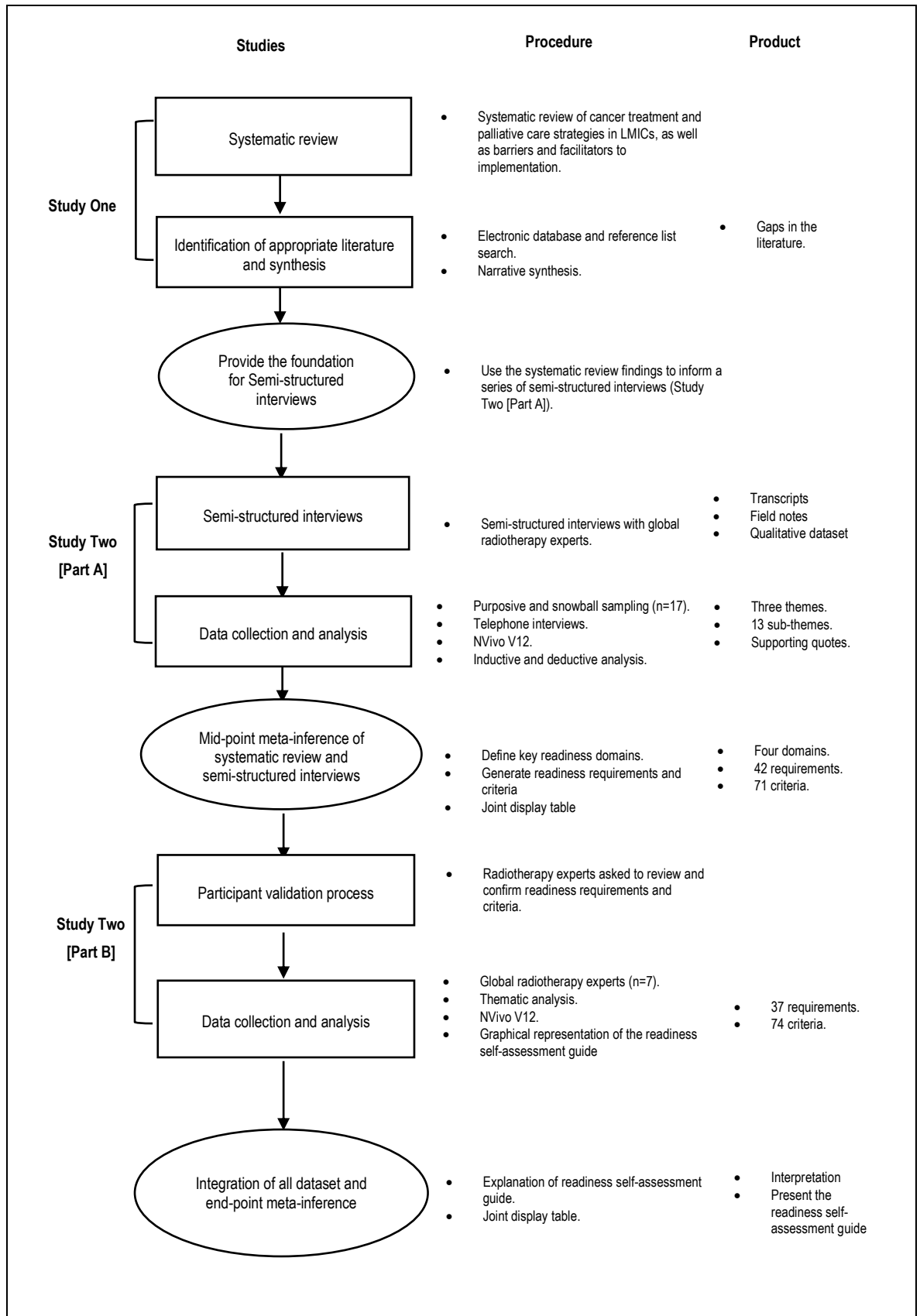


Figure 3.3: Sequential mixed qualitative methods design for the ARC Project

Adapted from (Morse & Niehaus 2016) and (Creswell & Clark 2018).

3.7.1 Integration through design

A pragmatic sequential mixed qualitative methods design consisting of a: systematic review (Study One); semi-structured interviews (Study Two [Part A]); and participant validation process (Study Two [Part B]) was suitable to gain a thorough understanding of how to successfully establish sustainable radiotherapy services in LMICs. In the ARC Project, the systematic review findings informed the subsequent semi-structured interviews. The qualitative questions in the interview guide elicited how and why participants feel a particular radiotherapy service was successful or unsuccessful in an LMIC.

Similarly, the findings from the semi-structured interviews with global radiotherapy experts informed the participant validation process. The data from the systematic review and the series of semi-structured interviews were transformed through mid-point meta-inference into readiness domains. Through the mid-point meta-inference, multiple readiness requirements were generated and subsequently validated through a participant validation process.

3.7.2 Integration through methods

In the ARC Project, methods of data collection and analysis for each Study were conceptually linked. Methodological integration occurred by connecting individual studies undertaken through sampling technique. The semi-structured interview (Study Two [Part A]) participants were chosen from the authors of articles included in the systematic review (Study One). Also, the validation study (Study Two [Part B]) participants were selected from the sample of participants who completed the semi-structured interviews (Study Two [Part A]). Analytical integration occurred by building on the findings of the systematic review, semi-structured interviews and participant validation data analysis. That is, the latter building on the former. Sentences and words participants used during the participant validation process informed the revision of readiness requirements and wording of new requirement.

3.7.3 Integration through interpretation and reporting

Integration of data at the interpretation and reporting level occurred through narrative and joint displays. The exact type of narrative integration was the contiguous approach. The contiguous approach to integration enabled the report of the systematic review, semi-structured interviews and participant validation process findings in different Chapters. Finally, integration through joint displays occurred by bringing the major findings from the ARC Project together through display tables and visual display tool, which allowed meta-inferences to be drawn to address the aim of the ARC Project.

The joint displays visually represented the connection between the different studies within the ARC Project and indicated the degree of data convergence (i.e whether enhanced, confirmed or new). Confirmatory data is when the current study reinforces the findings of the previous study.

Enhanced data is when the current study further improve the findings of the previous study while new data is when the current study provides findings not existing before in the previous study.

3.7.4 Transforming the readiness criteria into readiness questions

Through an iterative process of team discussion, revision and team input, the set of readiness criteria that define each requirements were transformed into questions after integrating all the data from the ARC Project. The readiness questions were developed for group practice. It was not expected that an individual radiation oncologist or medical physicist should necessarily be responsible for all actions addressed by the questions.

3.8 Ethical consideration in the ARC Project

3.8.1 Ethical approval

Ethical approval was obtained from the Faculty of Health, University of Technology Sydney Human Research Ethics Committees (Ethics approval number: ETH18-2187) (refer to Appendix I) for Study Two [Part A]. Study Two [Part A] required interviewing global radiotherapy experts to share their knowledge and experiences on establishing, strengthening and/or improving radiotherapy services in LMICs. The Study Two [Part A] was considered low and negligible risk ethical approval.

Study Two [Part B] required requesting global radiotherapy experts who participated in the Study Two [Part A] to confirm the generated list of readiness requirements. Study Two [Part B] was a participant checking; hence, ethical approval for the Study Two [Part B] was waived.

3.8.2 Informed consent

All participants were provided with an information sheet. The information sheet outlined the importance of the research, information about research procedures, and any risk of participant's involvement. Participants were informed that the main risk from the research is the inconvenience caused by allocating 30-45 minutes to be interviewed. Participants were also informed that they reserve the right not to answer any questions they prefer not to. Participants were notified that participation in the research was voluntary and they were permitted to decline participation without any consequences. On-tape verbal consent was obtained from all participants prior to interview commencement.

3.8.3 Values and principles of ethical conduct

The relationship between participants and a researcher is the foundation on which human research is conducted. Hence, the ARC Project was conducted in accordance with the National Statement on Ethical Conduct in Human Research, which is organised around respect for

participants, research merit and integrity, justice and beneficence (The National Health and Medical Research Council, the Australian Research Council & Universities Australia 2018).

3.8.4 Respect for participants

Respect for participants' rights and dignity as human beings was abided in the ARC Project. Throughout the ARC Project, participants were given the capacity to make their own decisions. Research activities such as interview date and time were negotiated with global radiotherapy experts to reduce inconvenience and disruption of their work schedule. The researcher respected the autonomous decisions about whether to participate in the ARC Project. Each participant was given complete information about the ARC Project and decided on their own whether to participate in the ARC Project. The researcher respected the perceptions, beliefs, privacy and information sensitivities of the participants and where relevant of the LMIC. Thus, participants were informed that they did not need to answer questions participants were not comfortable with.

3.8.5 Research merit and integrity

The ARC Project sought to develop a readiness self-assessment guide that can be used to gauge LMICs preparedness to establish safe and sustainable radiotherapy services. The ARC Project makes considerable contribution to knowledge and understanding of the processes involved in establishing safe and sustainable radiotherapy services in LMICs. The ARC Project was based on a thorough review of the current literature in cancer control in LMICs. The ARC Project protocol underwent multiple peer review processes at the at the: Graduate Research School researcher development programmes and workshops; Faculty of Health Research Students' Development Programme; and Improving Palliative, Aged and Chronic Care through Clinical Research and Translation (IMPACCT) Summer School to ensure the ARC Project was designed using methods appropriate for achieving the objectives of the ARC Project.

The ARC Project was supervised by a team (JP, TL and SA) with qualifications, competence and experience in cancer control research that were appropriate for the research. The ARC Project was conducted following the principles of research integrity, including: exploring knowledge and understanding; adhering to recognised principles of research conduct; conducting the research with honesty; and disseminating and communicating findings in a manner that permit scrutiny and add to public knowledge and understanding. Findings from the ARC Project have been shared through academic journals and peer-reviewed poster and oral presentations in both international and local conferences.

3.8.6 Justice

The participant inclusion criteria for the ARC Project was fair and accurately described as global radiotherapy experts involved in establishing, strengthening and/or delivering radiotherapy

services in LMICs, with at least two years experiences and could speak English. The process of recruiting participants was fair and there was no exploitation of participants in the conduct of the ARC Project. Findings from the ARC Project was shared with participants through a written report in a timely and clear manner.

3.8.7 Beneficence

The likely benefit of the ARC Project stretched to: i) international agencies and civil society organisations interesting in expanding access to global radiotherapy services; and ii) governments of LMICs planning to establish new radiotherapy services by providing them with a readiness guide that provides practical support to conduct self-assessment. The ARC Project was designed to minimise discomfort to participants. Participants were informed that the main risk from the ARC Project was the inconvenience caused by allocating 30–45 minutes to be interviewed. Participants were offered the right not to answer any questions they prefer not to.

3.9 Data management and security

All data from the ARC Project were stored in CloudStor, password-protected electronic location and on a hard disk which was locked in a cabinet within University of Technology Sydney Faculty of Health to ensure confidentiality and security of information in accordance with ethical standard. While the ARC Project was in progress, de-identified data were stored on the researcher's password-protected computer provided by the University of Technology Sydney.

Names and key identifying information were removed from transcripts and final report to protect participants' identity. Demographic information, such as age, gender, global role and length of service were reported in aggregate form.

Participants' privacy and confidentiality were ensured through the allocation of participant codes that were used throughout the data analysis and reporting. Participant's names were removed from all transcripts that were saved using participants' codes only on a password-protected computer. Only the researcher has access to ARC Project data. Participant's ages were removed from all publications. Participant's countries were broadly categorised as international and local. In accordance with national requirements, all ARC Project data will be stored for a period of five years (The National Health and Medical Research Council, the Australian Research Council & Universities Australia 2018).

3.10 Positioning the researcher and reflexivity

Reflexivity in qualitative research refers to the researchers' awareness of the different influences they may have on the research processes (Gilgun 2008; Probst 2015). Reflexivity considers the personal and social experiences of researchers vis-à-vis those of participants and the phenomena under investigation. Matters of importance to the reflexive process include

researchers' and participants' previous relationships, changes participants and researchers undergo in the course of the research process, and participants and researchers' experience and knowledge on the research subject (Gilgun 2008; Tong, Sainsbury & Craig 2007). Reflexivity is a way of sustaining an element of objectivity by admitting and addressing potential biases (Dowling 2006). Also, undertaking the reflexive process while planning, conducting and writing a qualitative research promotes transparency and encourages more realistic accounts of the research process (Probst 2015).

Prior to commencing as a full-time doctoral researcher based in Australia, I was a radiation therapist working in Ghana. As such, I am all too aware of the numerous challenges that LMICs face in establishing safe and sustainable radiotherapy services. Given my professional expertise, experience and insights and commitment to improving access to radiotherapy for all Ghanaians with cancer, I decided to focus on radiotherapy aspect of cancer care. This decision was not meant to lessen the importance of the other components of cancer control, such as prevention, pathology, or other modalities of treatment. Rather, it was hoped that focussing research on radiotherapy alone might be more manageable and therefore offer a greater likelihood of developing practical guidance to assist cancer control in LMICs.

In Study Two, the researcher (AD) openly introduced himself as a PhD candidate, with radiotherapy background from an LMIC in all electronic contacts with global radiotherapy experts who were potential and/or actual participants. Global radiotherapy experts were informed that the researcher was exploring factors that influence the establishment of safe and sustainable radiotherapy services in LMICs. This approach promoted transparency, collaboration and participatory. The open disclosure of professional background allowed a closer relationship, which made it possible to access information and knowledge throughout the data collection for both semi-structured interviews (Study Two [Part A]) and participant validation (Study Two [Part B]).

To begin each semi-structured interview, the researcher introduced himself to participants, introduced senior researchers that were in the interviewing room and explained the purpose of the ARC Project. All interviews were arranged around the schedules of the participants. Positive rapport and trust relationship with participants were created at the initial stages of the interview. Participants were informed not to answer questions that they were uncomfortable with. However, participants freely shared their experiences of both successful and unsuccessful radiotherapy initiatives. The researcher was careful to avoid asking questions that would constrain or bias the participants' answers.

There was no established relationship between the researcher and the participants before the ARC Project commencement. A respectful and learning attitude was the key to obtaining useful and reliable data. Participants were not suspicious of the ARC Project purpose. Instead, participants acknowledged the need to systematically explore the factors contributing to

successful or unsuccessful radiotherapy services in LMICs. Similarly, the researcher established useful network of relationships.

3.11 Reporting qualitative research

The reporting of the Study Two [Part A and B] was guided by the consolidated criteria for reporting qualitative research (COREQ) (Tong, Sainsbury & Craig 2007). The COREQ guideline is used by researchers for standardising qualitative evidence synthesis. Consequently, the following elements were included: i) description of the research team and reflexivity; ii) a detailed description of research design, which included theoretical framework, participant selection, setting and data collection; and iii) description of analysis and findings (Tong, Sainsbury & Craig 2007).

Trustworthiness demonstrates the truth, offers the basis for applying adopted techniques and allows for external judgements to be made about the consistency of procedures and findings. Credibility, dependability, transferability and confirmability were the four components of trustworthiness that guided the ARC Project (Tappen 2015).

Various strategies were used to achieve credibility. First, data were collected from different points of views, such as multiple disciplines in radiotherapy and participants with international and local experiences. Second, quotes were used to demonstrate links between participants' words and interpretations. Third, data were checked, and interpretations were verified by senior research team members.

Dependability was enhanced through documented decision-making and research team discussions as the ARC Project progressed. Also, all transcripts were checked multiple times for accuracy against the audio recordings. Similarly, reading and rereading of transcripts, as well as coding and recoding of texts heighten the dependability of the findings.

To achieve confirmability, transformed data in the form of readiness requirements were shared with participants for their feedback. Also, the researcher adhered to sound research practices by keeping a reflexive journal and recorded all information about the interviews, feedbacks, analysis and interpretations.

Finally, to improve transferability, detailed description of the setting, participants and rationale for each study were provided. The use of purposive and snowball sampling enabled transferability because they allowed us to develop new insights by providing a broad range of information from participants.

3.12 Reporting mixed methods research

The reporting of the mixed qualitative methods ARC Project is guided by the Good Reporting of a Mixed Methods Study guidelines (O'Cathain, Murphy & Nicholl 2008). Hence, the following

elements were included: i) the justification for using a mixed qualitative methods design to answer the research questions; ii) description of the design purpose; iii) description of each method in terms of sampling, data collection and analysis; iv) describing where and how data integration occurred; v) identifying strengths and limitations; and vi) describing any insights gained from data integration (Curry et al. 2013).

3.13 Summary

This Chapter has outlined the rationale for a pragmatic sequential mixed qualitative methods design, participants and setting, data collection and analysis techniques, as well as data integration, the researcher's position, ethical considerations and data management for the ARC Project. The next Chapter will discuss the findings of the series of semi-structured interviews (Study Two [Part A]).

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Chapter Four: Findings – Semi-Structured Interviews (Study Two [Part A])

4.1 Overview

As outlined in Chapter One, cancer is a major contributor to the global disease burden, particularly in LMICs with more than 10.3 million new cancer cases and 6.4 million cancer deaths in 2018 (Bray et al. 2018). These numbers are expected to increase because of population growth and ageing, changes in lifestyle and socioeconomic development (Bray et al. 2018). Radiotherapy is a critical component of cancer patients' management. In LMICs, almost two out of three cancer patients will require radiotherapy to cure or improve quality of life (Barton, Frommer & Shafiq 2006). But there is limited access to radiotherapy services in most LMICs (Zubizarreta, Van Dyk & Lievens 2017).

The systematic review findings presented in Chapter Two identified a scarcity of empirical studies reporting the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. This is despite the IAEA having worked collaboratively with LMICs for more than six decades to improve radiotherapy service access (Abdel-Wahab, Zubizarreta, et al. 2017), including: the development of technical documents regarding safety, quality assurance, commissioning and staffing of radiotherapy services (Brown et al. 2014; IAEA 2014; IAEA 2015).

The IAEA-Programme of Action for Cancer Therapy has been assisting LMICs to evaluate and plan their national cancer control programmes since 2004, with the progress made attributed to the WHO and the International Agency for Research on Cancer to control cancer support and commitment of the program goals (Abdel-Wahab, Lahoupe, et al. 2017). Of equal importance has been the Global Task Force on Radiotherapy for Cancer Control, which has quantified the investment required to achieve equity in radiotherapy access and the substantial return on that investment (Atun et al. 2015). This advice is important as it publicly acknowledges the importance of universal access to radiotherapy, and details the role of global advocacy and appropriate supports for LMICs to deliver on this promise (Atun et al. 2015; Yap et al. 2017). While global efforts to improve access to radiotherapy services has increased (Donkor et al. 2018), little could be gathered from the existing literature about the factors that influence the successful establishment of safe and sustainable radiotherapy services in LMICs.

In order to better understand the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, it was decided to interview global radiotherapy experts involved in establishing, strengthening and/or delivering radiotherapy services in LMICs. Methods for this study were reported in Chapter Three.

The semi-structured interviews with global radiotherapy experts was published in 2020 in the *Asia-Pacific Journal of Clinical Oncology*. Chapter Four contains an expanded version of the finding and discussion from the publication, which is provided in Appendix J.

4.2 Publication reference

Donkor, A., Lockett, T., Aranda, S., Vanderpuye, V. & Phillips, J.L 2020, 'Experiences of barriers and facilitators to establishing and sustaining radiotherapy services in low- and middle-income countries: a qualitative study', *Asia-Pacific Journal of Clinical Oncology*, pp. 1-12.

4.3 Objective

To identify and describe the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs.

4.4 Methods

The method for the semi-structured interviews undertaken with global radiotherapy experts are described in detail in the Chapter Three.

4.5 Findings from the semi-structured interviews (Study Two [Part A])

Characteristics of participants

Forty invitations were sent to a global pool of potential participants. Twenty-three were unable to participate for the following reasons: incorrect email address (n=10); no response after follow-ups (n=7); workload and annual leave restrictions (n=3); travelled overseas (n=1); potential conflict of interest (n=1); and failure, without a reason to attend the scheduled interview (n=1). A total of 17 participants took part in Study Two [Part A] (42.5% response rate), including 12 males and five females. The majority were radiation/clinical oncologists (n=11) with a smaller number of medical physicists (n=3), radiation therapists (n=2) and an administrator. Ten participants were working permanently in either: Ethiopia, Egypt, Brazil, Kenya (n=2), Jordan, India, Nepal, Peru and Zambia (n=1). All of the remaining participants (n=7) were permanently employed in four HICs [Australia, (n=3), Canada, (n=2), USA (n=1) or Qatar (n=1)] but had been involved in various initiatives to strengthen radiotherapy in multiple LMICs. Interviews lasted an average 35 minutes (range: 30 – 50 minutes).

Emergent themes and sub-themes

Despite participants' diversity of experiences across LMICs, three major themes and 15 associated sub-themes were identified as critical to establishing safe and sustainable radiotherapy services in LMICs (refer to Appendix K for a list of barriers and facilitators). The major themes were: 1) committing to a vision of improving cancer care; 2) making it happen and

sustaining a safe service; and 3) leveraging off radiotherapy to strengthen integrated cancer care.

4.5.1 Committing to a vision of improving cancer care

Political environment. There was unanimous agreement that committing to a cancer control vision, political stability and basic infrastructure like the quality supply of electricity were prerequisites to successful radiotherapy service establishment. A critical success factor was the political will to support establishing radiotherapy services with the capacity to meet the service demands of the population:

...with the support of the Ministry of Health...six centres and teaching hospitals were selected to start cancer care, including radiotherapy (P10, CO, Male, 37 years, Local).

Most participants perceived that an LMIC's inability to commit and establish radiotherapy service was linked to political impasses, periodic changes of political leadership, bureaucratic corruption, multiple competing political demands and policymakers' negative misperception about investing in radiotherapy:

There's a misperception that radiotherapy is expensive...and that comes from the fact that there is a barrier to entry associated with how much it costs to buy a linear accelerator...It's one of the reasons the Global Task Force on Radiotherapy for Cancer Control...analysis is very important (P5, RO, Male, 57 years, International).

Advocacy. Participants described the availability of 'vision champions' as essential to convincing decision-makers that investing in cancer care was important. 'Vision champions' were recognised as good negotiators and networkers, resilient, enthusiastic and trustworthy individuals or groups who provided leadership and advocacy for improving access to radiotherapy services:

[You need] someone that has some sort of clout...that will listen to...a university professor, or physician, or a senior medical physicist, or even someone that works in the government already (P4, MP, Male, 34 years, International).

A public figure being diagnosed with cancer often provided the impetus for LMICs' political leaders to suddenly commit to radiotherapy projects to establish radiotherapy services. These opportunities needed to be carefully managed to optimise the country's investment to achieve the best outcome for the entire population:

...[even when] there are no resources, a First lady gets breast cancer...and suddenly these resources appear...often these VIPs would travel to Europe or North America for treatment and then they would come back and say, "We want all the bells and whistles that we saw" (P3, RO, Male, 70 years, International).

Radiation safety. Participants stressed that a critical first step was for an LMIC to become a member of the IAEA and develop country-wide radiation safety laws to ensure timely approval of the radiotherapy plan before the commencement of the facility construction:

...countries have to apply for membership in the IAEA...As part of membership, they may have to pay a modest fee...but then they are also required to have some legislation in place, for accountability of the radioactive materials (P3, RO, Male, 70 years, International).

Costed cancer control policy with radiotherapy implementation plan. Participants described the importance of having a country-wide radiotherapy implementation plan. Having a costed country-wide cancer control policy with a radiotherapy implementation plan demonstrated the government's commitment to control cancer and theoretically address many of the barriers that participants identified namely, fragmented services and inadequate geographical coverage:

...you need radiotherapy to be installed within a comprehensive national cancer control program. So, you need the cancers that are preventable being prevented. You need early detection so that the cases that are coming into radiotherapy are maximised... Then you're palliating the ones that can be palliated (P15, RT, Female, 49 years, International).

Participants suggested a significant barrier to a comprehensive cancer control vision was the lack of reliable epidemiological data, essential to developing a country-wide radiotherapy plan. Epidemiological data was key to developing the investment case, determining the optimal location and type of technology that would best serve the populations' needs:

...what we are doing is to prepare a roadmap as to which states should have equitable radiotherapy access. Because just stating that a country needs 40 radiotherapy or brachytherapy units without knowing where they are required, ends up that many are [established] in major cities (P11, RO, Female, 47 years, Local).

Identifying a funding model. Participants identified a viable funding model as crucial to ensure a country was able to commit to construction, equipment set-up and maintenance, and workforce development. Participants described multiple funding models, including public, private, public-private partnership and charitable. Regardless of the model, long-term funding was critical to consider from the outset to ensure a safe and sustainable radiotherapy service:

You have to start looking at the long-term plan. The cost-effectiveness reflects in sustainability (P4, MP, Male, 34 years, International).

Participants acknowledged that a well-framed business case that demonstrated radiotherapy benefit, financial, technical and operational viability was essential to securing financial commitment. Some countries have adopted public-private partnership strategies where the private sector finance, design, build, operate and maintain the facility for an agreed duration before handing over the responsibility to the public sector. Such partnerships were essential; however, it was a challenge when the country could not sustain the facility.

...there is a little bit of a trend... where a company will come in with what they call a turn-key solution. So, they will come in [country] and they will build the building, put the equipment in, commission the equipment, get it ready to go, and in some cases put workforce in there for a period of time... Then they walk away... and...turn over to local people to run and operate (P15, RT, Female, 49 years, International).

While the private sector was recognised as an important source for financing a country's radiotherapy vision, it did not always promote equity of access and often created financial hardships for poor households without health insurance. Participants highlighted the vital role of charities and civil society organisations in mobilising funds through community engagement, philanthropic and political commitments to addressing barriers, such as financial risks associated with accessing radiotherapy. However, arriving at a subsidy agreement required lobbying:

...government is subsidising...diseases like cancer, kidney, and heart...\$1000 (US) per patient...we lobbied with the Ministry of Health...met the Prime Minister (P14, Administrator, Male, 63 years, Local).

4.5.2 Making it happen and sustaining a safe service

Executing a plan to establish a new radiotherapy service required project management inclusive of planning, construction, procurement, delivery, installation, commissioning and workforce development. International support at critical junctures, along with concurrent sustainability and contingency plans to manage unforeseen events which threatened the delivery of a fully function radiotherapy service on time and budget are also required.

Building the facility and purchasing the right machinery. Securing a suitable location with space for future expansion and constructing the facility was recognised as a challenging task because of the need for resources. The right balance of local knowledge and international expertise helped to meet the safety and operational requirements.

...we had a local architect who could collaborate and share the drawings with an international person to critique and give input (P9, CO, Female, 49 years, Local).

Without a competent project management team, there was a risk of the building process being derailed due to poor stakeholder engagement and suboptimal decision-making, which contributed to cost overrun, project failure and damaged reputations. Participants also highlighted the power differential between local teams and powerful, for-profit vendors. They described how vulnerable many LMICs were when negotiating with larger vendors and how this vulnerability was amplified if there was a lack of tendering and contract management experience within the team:

In [HICs], when we decide we want to buy a new machine, we have these experienced physicists who lead the negotiations...But you can imagine that, if the country has no experience in that, the vendors will be dictating (P1, RO, Female, 37 years, International).

Establishing collaborative relationships with centres of excellence and seeking technical assistance during the early planning stages was critical. Participants emphasised challenges in equipment licensing requirements at local regulatory levels, resulting in application processes being frustrating and hampered by long delays. Participants highlighted the important contribution from international experts, many of whom are volunteers. They ensured that radiotherapy equipment was correctly commissioned. Many of these experts, make a significant financial and/or time sacrifice to be based in an LMIC for anything up to a year:

... we've [international organisation] had...a medical physicist...there for 12 months...for their machine commissioning (P1, RO, Female, 37 years, International).

Building the radiotherapy workforce. Building the radiotherapy workforce was essential to the operation and management of any radiotherapy facility. Providing radiotherapy service safely required a core team of well-trained radiation oncologists, radiation therapists and medical physicists. This team needs to be in place before the radiotherapy service can commence. The absence of a suitably trained workforce has led some LMICs to resort to inappropriately substituting other health professionals into radiotherapy roles they were not qualified to perform, jeopardising patient and staff safety:

...often many departments are very keen to come on-board with new technology straight away when there has not necessarily [been any] training...the therapists are often...nurses...and told, "Okay, now you're the radiation therapist," with very little training (P1, RO, Female, 37 years, International).

Overseas training for staff was perceived as unavoidable when establishing radiotherapy for the first time but was criticised as being expensive with different disease pattern and technology compared to types of equipment and cases of patients treated in most LMICs. Also, overseas training risked the loss of local talent due to a better standard of living, attractive incentives, stable political environment and access to advanced technology in HICs. As the length of

workforce preparedness was lengthy, participants highlighted the need for workforce development to occur before the installation of the equipment to prevent redundancy.

In one case...the facility was ready, the equipment was installed, but the trainees were not ready...and what happened during that time, rats and mice basically ate up the wiring (P3, RO, Male, 70 years, International).

Creative approaches to workforce development were required, including a range of local and international solutions that addressed barriers like insufficient qualified teachers and lack of mentors. They mentioned initiatives such as: e-learning platforms like Virtual University for Cancer Control, Africa Radiation Oncology Network and Chartrounds; and 'train-the-trainers' initiatives by Radiating Hope and Asia Pacific Radiation Oncology Special Interest Group of Royal Australian and New Zealand College of Radiologists:

Since the last one year or two through a partnership with American Society [of Radiation Oncology] International Outreach Program, Chartrounds, is available to us...It's a digital conferencing with weekly at least 30 to 40 radiation oncologists join in to promote education and training (P11, RO, Female, 47 years, Local).

Availability of appropriate incentive systems, which included financial and non-financial incentives was described as crucial in attracting and retaining radiotherapy workforce.

Gaining and maintaining financial stability. After the initial investment in establishing the radiotherapy facility, gaining and maintaining financial stability was crucial for operational sustainability. Participants described out-of-pocket payments, prepaid payment plans, social security funds, sustained donor pipeline, public taxes, government revenues and subsidies as payment models adopted to generate funds to sustain facility operations:

...we open our hospitals to investors 24 hours a day. So, investors may come and have a tour in the hospital. We show them how we treat our patients...that encouraged the people to donate (P8, RO, Male, 67 years, Local).

Regular maintenance. During contract negotiations, it was essential to include an equipment maintenance clause to ensure equipment was serviced regularly, and parts could be readily sourced to minimise downtime. Expensive spare parts, lack of dedicated funding, poor spare parts supply and distribution, as well as lack of qualified engineers were identified as major barriers to maintaining radiotherapy services.

...all these machines are coded in American dollars...our currency is not very good right now...So, they say, 'Okay, we don't want the machine anymore because you're giving the machine you are not giving money for the next five years to maintain the machine (P13, RO, Male, 33 years, Local).

Establishing innovative infrastructure maintenance and replacement policies and building a critical mass of equipment from the same vendor were recommended to address most of the named maintenance challenges:

What typically happens is every country does its own thing and buys whatever they like...What I would recommend is if there was a cluster of countries...they all go with the same equipment vendor...so that you can have an engineer based in one of those countries that can swing around (P15, RT, Female, 49 years, International).

Building research culture and infrastructure. Producing quality data about service performance and improvement was identified as key to further funding commitments from investors. Radiotherapy was thus best recognised as a valuable contribution to cancer control when there was a capability to finance long-term investment in collaborative research to produce innovative solutions:

...we have active groups in medical oncology and active groups in radiotherapy. We are investigating the ways of making better medicine with cheaper expenses (P12, RO, Male, 73 years, Local).

Good governance and management. Critical to the successful provision of the broad range of clinical and non-clinical services was good governance and management team. Having an inclusive governance and management structure ensured there was a good representation when making decisions to provide quality care. Participants suggested that to be sustainable, it was critical for the facility management team to have a high degree of accountability, transparency and a culture of continuous expansion:

...is a charity hospital...but...we are...continuously expanding...there are two linear accelerators...And we started with 120 beds, but now 303 (P8, RO, Male, 67 years, Local).

Improving patient outcomes. An important consideration identified was how the facility sustains patient flows in an ever-growing competitive environment. Creating a reputable brand by having a high-quality infrastructure, adopting evidence-based practices and engaging patients were facilitators that impacted patients' outcomes; hence, were crucial in gaining patients and donors' trust, loyalty and commitment. A further success factor was ensuring that social support systems for patients addressed both medical and non-medical costs when accessing radiotherapy:

It's about the extra small things that they [patients] want...when they [patients] are lodging at the hospital, meals are provided, three meals a day for free (P16, CO, Female, 36 years, Local).

4.5.3 Leveraging off radiotherapy to strengthen integrated cancer care

Establishing a radiotherapy service was suggested to be the foundation for developing integrated cancer services inclusive of a comprehensive care strategy, multi-disciplinary approach and information technologies to improve outcomes.

Catalysing comprehensive care and support service. Achievement of a radiotherapy service can play a central role in catalysing the development of comprehensive cancer infrastructure to address all necessary aspects of cancer control. A stepwise approach with achievable roadmaps was vital:

It [radiotherapy] certainly can be a driver if you like to bring cancer services together...you do have to build custom infrastructure and facilities...it tends to be, well rather than just build a radiotherapy centre, let's build a cancer centre...I have seen it work like that (P15, RT, Female, 49 years, International).

A multidisciplinary approach to care. Participants emphasised the importance of building a multidisciplinary team with a patient-centred comprehensive care goal. Two models of a multidisciplinary approach to care were identified, which included: multidisciplinary clinics; and multidisciplinary cancer conferences to discuss the diagnostic and treatment of cancer patients' care. They suggested that collegial relationships, commitment to regular meetings and availability of operational policies or protocols to standardise care were essential characteristics of a successful multidisciplinary team approach. However, some participants perceived differences between professional perspectives and lack of understanding of the role of radiotherapy created challenges committing to a multidisciplinary path:

Surgeons want to be the owners of the patient, so they want to...bill, they want to get more treatments to the patient, and will only refer to radiation in most of the cases when they cannot do anything else (P13, RO, Male, 33 years, Local).

Information and communication technologies (ICTs). Participants described how the availability of ICTs contributed to effective integration. The primary objective of implementing ICTs was to improve patient outcomes. Another critical objective was to promote the training of the radiotherapy workforce. Participants explained ICTs as electronic enabling tools for processing and disseminating clinical and non-clinical information to aid effectiveness:

...we have a hospital information system in which this referral is [documented]...every person in the hospital has access to this hospital information system (P8, RO, Male, 67 years, Local).

4.6 Discussion

This qualitative study provides novel exploratory insights into the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, which demonstrates that radiotherapy service establishment is a complex large-scale initiative. Regardless of the global radiotherapy experts' geographical location, establishing safe and sustainable radiotherapy services in LMICs were expressed as three interrelated factors. First, commitment to a vision was described as the willingness and dedication of policy- and decision-makers to support plans to expand access to cancer care, including radiotherapy services. Second, making the radiotherapy service plan happens and sustaining the service involved project management capabilities (strategic planning and coordination) and capacity, such as the availability of human, financial, equipment, infrastructure and information technology resources. Third, leveraging off the established radiotherapy service was described as using the available radiotherapy service as a window of opportunity to strengthen integrated cancer care.

A country-wide cancer control plan is essential to define and maintain a clear vision. The vision to initiate a country-wide cancer control plan can be conceived by the ministry responsible for health, a healthcare professional, local civil society organisation or a combined effort with international organisations. The role of the healthcare professional is no longer only to deliver care but as advocate and gatekeepers of mobilising resources for the entire population. In advocating for a radiotherapy service as part of cancer control plan, the IAEA can play a facilitating role by advocating with member LMICs or providing technical support during the planning and implementation of the cancer control plan through the IAEA- Programme of Action for Cancer Therapy initiative. The success of advocating for a radiotherapy service may be dependent on accessing evidence to frame a compelling case, working in close collaboration with relevant stakeholders and identifying window of opportunity to lobby decision-makers to take action on the radiotherapy service gap. Building a robust and coherent evidence can influence policy and investment decisions. Evidence describing the burden of cancer can help advocate for its urgency and the need for feasible solutions (Lowery 2013). The UICC together with other international agencies, academic institutions and academic journals have been building evidence systematically to: change policies of governments; influence attitudes and behaviours of policy- and- decisionmakers; and build capacity of clinicians and local civil society organisations to engage in cancer control policy- and decision-making.

Access to accurate local data is critical for effective planning (Morgan et al. 2018). Decisions and actions to establish a radiotherapy service ought to be based on the analysis of epidemiological data and not only on opinions. Epidemiological data on the common cancer and their stage at diagnosis are crucial to inform radiotherapy service planning and decision-making, such as target population of interest and equipment type. Population-based cancer registry and hospital-based cancer registry are critical for collecting, storing, analysing and interpreting data on cancer cases and deaths. The value of a cancer registry is reliant on the quality of the data

collected but not the quantity (Menck 2011). However, the situation remains that most LMICs lack cancer registries to inform cancer control actions, including planning and implementing radiotherapy services (Bray et al. 2018). Developing safe and sustainable radiotherapy service requires investment in initiatives to strengthen cancer registry and research capacity (Atun et al. 2015; Lievens et al. 2017). Through partnerships at the international level, the Global Initiative for Cancer Registry Development is empowering countries to advance information systems for cancer control (Bray et al. 2014). While trends in cancer incidence and mortality are needed, it is essential to develop a cancer survival database to inform service design and continuous improvement.

Funding arrangements are crucial to establish and sustain radiotherapy services. Developing long-term funding arrangements help balance available resources to meet current radiotherapy service needs, as well as financially sustain the radiotherapy service after the initial investment. However, in most LMICs state-of-the-art radiotherapy facilities are often established out of a sense of political and/or social service with limited focus on sustainability. Radiotherapy service financiers ought to understand the complexity of LMICs and the role they can play to achieve operational and financial sustainability of the radiotherapy service. In some LMICs, funding for establishing radiotherapy services comes from governments through loans provided by multilateral development banks, such as World Bank, African Development Bank and Organisation of the Petroleum Exporting Countries Fund for International Development. In other LMICs, funding for establishing radiotherapy services usually comes from private and charitable sources, with civil society organisations playing a crucial role in initiating a wide variety of public fund raising and donation mechanisms.

Multi-sectoral partnership is also an approach that drives financial resources to initiate projects to establish radiotherapy services in some LMICs. Nevertheless, the success of multi-sectoral partnership is dependent on each partner gaining a comprehensive understanding of the radiotherapy service needs, which provides all partners the opportunity to contribute to the development, implementation and sustainability of the radiotherapy service. Partnerships with public sector, private sector, civil society organisations and/or academic institutions can drive support and sustain commitment that may positively impact cancer control in LMICs. A recent example of a multi-sectoral partnership initiative is the City Cancer Challenge (Adams et al. 2017). In 2017, based on the three Lancet Oncology Commissions' reports and a recognition that governments were not investing the necessary resources to implement the national cancer control plans developed, UICC launched the City Cancer Challenge (Adams et al. 2017; UICC 2017).

Previous city initiatives, such as Healthy Cities Initiative and New York City Initiative have shown that cities can lead the way to reducing mortality associated with communicable diseases and NCDs (Norris & Pittman 2000; Ong et al. 2017). The City Cancer Challenge strategy is to collaborate with and support cities to lead the design, planning and

implementation of cancer treatment interventions (Adams et al. 2017). The City Cancer Challenge initiative seeks to increase equity of access to quality cancer treatment in cities around the world via multi-sectoral partnerships with city leaders, governments, international agencies and organisations, academic institutions and private sectors (Adams et al. 2017; UICC 2017). The City Cancer Challenge is also aligned with Treatment for All initiative, which is an advocacy campaign by UICC with expertise, political supports and other partners to address gaps in access to cancer data, early detection and diagnosis, treatment, and supportive and palliative care (Adams et al. 2018). Building countries' capacity and leadership in the delivery of cancer care through technical assistance and financial resources are essential pillars of City Cancer Challenge (Adams et al. 2018; UICC 2017).

Irrespective of the funding source, political commitment is integral to facilitate resource mobilisation and allocation. Governments ought to recognise radiotherapy service as a critical driver of economic growth (Atun et al. 2015). A well-managed facility can function for almost 40 years and the equipment can operate for about 20 years (Kamanzi et al. 2016). However, equipment becomes less efficient after 10 years and spare parts are harder to obtain and more costly. Radiotherapy equipment is often the largest capital investment when establishing a radiotherapy service in LMICs. Having strategic maintenance and replacement policy is critical to minimise downtime while prioritising equipment that needs to be replaced (IAEA 2010). Both scheduled and unscheduled maintenance are required during the radiotherapy equipment lifetime. Radiotherapy centres ought to have a team of highly trained and qualified engineers to manage and maintain the radiotherapy equipment during its lifetime. Also, establishing a multidisciplinary equipment maintenance team that assist the radiotherapy governance and management board in maintenance decisions. For example, equipment maintenance team could regularly evaluate the existing radiotherapy equipment in terms of functional and operational capabilities to meet clinical standards. Radiotherapy equipment may deteriorate faster than expected if the operational demand is high; hence, quality assurance, equipment assessment and auditing ought to be performed periodically to determine the benefit of acquiring new radiotherapy equipment.

Consistent with several studies in health and non-health, the findings indicate that effective project management is crucial for achieving radiotherapy service establishment (Badewi 2016; Brown et al. 2014; Sanchez & Terlizzi 2017; Santos et al. 2014). Managing the radiotherapy project involves planning, organising, leading, coordinating implementing and controlling all the project activities to achieve the goal of establishing a safe and sustainable radiotherapy service within the constraints of time, resources, budget and scope. Managing projects to establish new radiotherapy services in LMICs is challenging because each radiotherapy project is unique. Also, most LMICs lack expertise and experience because they have never established a radiotherapy service before. Other challenges may emerge from the multiple stakeholders' expectations, implementing collaborative network among stakeholders from different contexts,

communication challenges, difficulties of estimating the workload and timelines by taking into consideration the unknown barriers and competing demands, such as time and resources. As a result, appointing a project manager is integral to the success of the project to establish a new radiotherapy service. Besides the fundamental project management skills, the radiotherapy service project manager ought to have technical knowledge about radiotherapy, effective communication skills, good leadership skills and business management skills, such as finance, budgeting and procurement (Project Management Institute 2017). In situations where the LMIC is establishing radiotherapy service for the first time and the right expertise is unavailable, recruiting external expertise is essential (IAEA 2014).

Sustaining radiotherapy services in LMICs is achievable but requires capable and well-equipped radiotherapy workforce. Radiotherapy workforce are healthcare professionals with specialised training whose primary aim is to combine skills, knowledge, precision, accuracy and complex technology to deliver radiotherapy safely. A well-functioning radiotherapy workforce is one that is available, skilled, knowledgeable and responsive (WHO 2007). However, most LMICs lack training and educational institutions, as well as regulatory mechanisms such as licensing and accreditation to improve quality of radiotherapy practice. Also, most LMICs have no built-in continuing professional development programme after initial formal training. Continuing professional development is critical for radiotherapy workforce because it ensures staff continue to be competent in radiotherapy practice. The goal of continuing professional developments is to ensure that radiotherapy staff continue to deliver high quality radiotherapy service that safeguards the public and meets the expectations of people living with cancer and their families (Rosenblatt et al. 2017). Opportunities ought to be created to enable LMICs develop appropriate strategies to address radiotherapy workforce training, education, regulation and retention.

The findings reinforced those of previous evidence that depending on overseas training is unsustainable because it promotes brain drain from LMICs to HICs (Eriksen 2017; Ngwa & Ngoma 2016). Tailored in-country education and training initiatives are emerging in some LMICs and have proven successful (Balogun et al. 2017; Jalan et al. 2019; Zubizarreta et al. 2015). Technological advances have a place in the radiotherapy workforce education and training. Technologies such as tele-mentoring, tele-oncology or tele-radiotherapy have helped overcome many of the barriers related to conventional face-to-face teaching, including: logistical challenges; distance barrier; access to expertise; learning materials; and collaborations challenges. E-resources such as email support, electronic library resources, online discussion forum and social media platforms like LinkedIn have created multiple opportunities and flexible environment for accessing knowledge. For example, Africa Radiation Oncology Network and Virtual University for Cancer Control by IAEA and 'train-the-trainers' supportive approach by Radiating Hope, Asia Pacific Radiation Oncology Special Interest Group of Royal Australian and New Zealand College of Radiologists and Medical Physics for World Benefit have given LMICs

new tools and resources through which they can interact with their colleagues (Chhem et al. 2010; Coleman et al. 2014; Dad et al. 2017; Eriksen 2017; Yap et al. 2017).

Also, to bridge the gap in cancer workforce, the UICC technical fellowships provide one-month international visits that allow the international exchange of cancer control knowledge and skills in cancer prevention, diagnosis and treatment (UICC 2020b). The UICC technical fellowships have supported the development of over 4,000 cancer care professionals from over 110 countries (UICC 2020b). The African Cancer Fellowships is another cancer care workforce capacity building initiative developed by UICC with the support of American Cancer Society. The focus of the African Cancer Fellowship is to improve cancer outcomes in Africa through hands-on fellowship opportunities, with peer-to-peer support and information sharing (UICC 2020a).

Also, LMICs establishing links with radiotherapy centres in HICs, regionally and/or locally is vital in improving technical support, maintaining regular communication and sharing knowledge and information to ensure sustainable radiotherapy services (Barton, Frommer & Shafiq 2006; Coffey et al. 2006). Technical assistance involves sharing radiotherapy knowledge and expertise with the goal of improving quality of radiotherapy services in LMICs, which makes the 2005 Paris Declaration on Aid Effectiveness important. The Paris Declaration on Aid Effectiveness is a set of commitments designed to make aid more effective for development (Dickinson 2011; Organization for Economic Co-operation Development 2008). The Paris Declaration provides an opportune moment for governments, civil society, academia and private sector to forge global movements through advocacy and support to control cancer in LMICs while holding donors and recipients accountable. Thus, the Paris Declaration provides the opportunity to put in place an independent, robust and transparent system for international aid to expand access to cancer treatment through a collaborative mechanism.

Collaborative technical assistance in radiotherapy could involve a wide range of support and resources, including: performing a need assessment; assisting with equipment commissioning; consulting; training; mentoring; and clinical problem solving (Abdel-Wahab et al. 2013). Defining the type of activities and support when establishing a collaborative assistance programme is considered critical to avoid misunderstanding and premature assumptions about the solutions offered through the technical assistance. The collaborative technical assistance may be influenced by several readiness factors, such as: radiotherapy leaders' willingness to collaborate; radiotherapy centres history of technical assistance programme; teams' motivation to engage collaboratively; ability to obtain staff input; environment that promotes peer-to-peer learning; and readiness to build staff competencies through hand-on activities (Chaple & Sacks 2016; Chilenski et al. 2016; Donkor et al. 2018).

The findings also indicate that in some LMICs multidisciplinary care for people living with cancer is often facilitated by leveraging off the availability of radiotherapy services. The care of people

with cancer requires the combined efforts of a multidisciplinary team of healthcare professionals to cure or improve the quality of life (Yeung, Escalante & Gagel 2009). The multidisciplinary team of healthcare professionals ought to communicate with each other as well as cancer patients and their families to deliver patient-centred care based on available scientific evidence. The availability of a radiotherapy service presents a promising path to developing clinical guidelines and bringing skills of multiple surgical oncologists, medical oncologists, radiation oncologists, radiologists, pathologists, dieticians and other healthcare professionals that exceed that of a single provider.

The findings of this study have established the complexity of establishing and sustaining radiotherapy services highlights the importance of conducting readiness assessment prior to developing radiotherapy services in LMICs. To achieve an objective assessment of LMICs' readiness often proves to be challenging due to the lack of requirements and criteria. Providing a relevant readiness self-assessment guide is imperative. The factors identified in Study Two [Part A] provide a promising starting point. It will also be important to strengthen the various innovation programmes for researching and developing innovative technologies to address most of the identified radiotherapy challenges. Thus, LMICs have opportunities to invest in potentially 'leapfrog' radiotherapy technologies. Like mobile diagnostic units, mobile radiotherapy service delivery models can make a significant impact on access to radiotherapy service in LMICs. There is value in sharing lessons learned from radiotherapy implementation in a global context.

4.6.1 Strength and limitations of Study Two [Part A]

The strengths of Study Two [Part A] are: participants had varied experiences in establishing, strengthening, sustaining and/or delivering radiotherapy across LMICs; we involved the views multiple disciplines within radiotherapy, thus increasing our confidence in the data. The sample size of Study Two [Part A] was enough to capture and understand broad themes related to radiotherapy service implementation, which will enable us to develop item requirements and criteria for a future survey with a large sample size. A few limitations are important to mention. First, participants were required to recount their experiences and may have created recall bias. Additionally, facial expression and body language were not taken into consideration because the interviews were through audio devices.

4.7 Conclusion

Study Two [Part A] identified several barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. Identified examples of successful radiotherapy services in LMICs were largely achieved through strong political support, advocacy activities of vision champions, diversified sources of funding, strategic partnerships, costed cancer control plan, adoption of evidence-based practice, prepared workforce, technical assistance from IAEA

and other expert volunteers, well-negotiated service contract and international and/or regional research collaborations. Assessing the level of readiness to establish and sustain a radiotherapy service appears to be important. Future research is recommended to develop a readiness self-assessment guide for the establishment of radiotherapy services in LMICs.

4.8 Summary

This Chapter has presented the findings of a series of semi-structured interviews with global radiotherapy experts. The semi-structured interviews' findings (Study Two [Part A]) identified a complex picture of the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs. Therefore, developing a readiness self-assessment guide could provide greater understanding of these complex factors and support LMICs when they are setting out to establish safe and sustainable radiotherapy services. The next Chapter reports the mid-point meta-inference by integrating the data from the systematic reviews (Study One) and semi-structured interviews (Study Two [Part A]).

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Chapter Five: Mid-Point Meta-Inferences

5.1 Overview

Chapter One reported on cancer as a contributor to the global disease burden, including in LMICs. It also introduced the two conceptual frameworks underpinning the ARC Project, namely: the WHO's Innovative Care for Chronic Conditions Framework and Health System Building Blocks Framework for Action (WHO 2007; 2002).

As presented in Chapter Two, the systematic review (Study One) identified few studies (n=4) reporting barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs (Donkor et al. 2018).

Chapter Three detailed the ARC Project's pragmatic sequential mixed qualitative methods design. It also described the integration of the various ARC Project's data sets, and described how the mid- and endpoint meta-inference would be used to answer the ARC Project's three research questions.

As outlined in Chapter Four, the findings from the semi-structured interviews with global experts in radiotherapy (Study Two [Part A]) identified significant barriers to establishing safe and sustainable radiotherapy services in LMICs, as well as the facilitators that could be exploited to develop quality radiotherapy services for people living in these less-resourced settings. In particular, this study highlighted a need to assess the readiness of LMICs against a range of requisites for the establishment of radiotherapy services being successful.

This current Chapter reports on the mid-point meta-inference which integrates the data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]) to gain a deeper understanding of the barriers and facilitators that need to be considered by LMICs planning to develop a local radiotherapy service. It also explores the concept of readiness and why this concept is important for LMICs to consider when planning a new radiotherapy service. Emerging from this meta-inference is a draft radiotherapy service development readiness self-assessment guide, which is configured to provide practical advice and guidance to LMICs considering embarking on establishing safe and sustainable radiotherapy services.

5.2 Objective

To develop a set of potential radiotherapy service development readiness requirements for use by LMICs establishing safe and sustainable radiotherapy services.

5.3 Methods

The methods for the mid-point meta-inference of the Study One and Study Two [Part A] are reported in detail in the Chapter Three.

5.4 Discussion of the ARC Project's mid-point meta-inference

The ARC Project's mid-point meta-inference of Study One and Study Two [Part A] data sets confirmed many of the factors identified by the systematic review, but also added many new insights from the semi-structured interviews. The findings generated from the mid-point meta-inference are presented in the joint display table (refer to Table 5.1) and summarised in the narrative below.

A large number of the identified factors acted as 'facilitators' and the reverse was true as 'barriers', depending on the situation. This reality was most evident in relationship to: epidemiological data and integrated cancer control policy; radiation safety legislative and regulatory framework; political leadership; awareness and advocacy; financial resources; project management; radiotherapy workforce training and education; basic physical infrastructure; governance and management structure; information and communication technologies; and research collaboration.

5.4.1 Epidemiological data and integrated cancer control policy

The ARC Project's mid-point meta-inference provided new insights into the urgent need for reliable epidemiological data to inform the development of cancer services commensurate with the local burden of cancer. Without robust epidemiological data, it is difficult for LMICs to develop a coherent cancer control policy and plan that reflects the action required to reduce the local cancer burden and to develop targeted cancer services. Defining a country's cancer profile is often reliant on epidemiological data extracted from routine information collected at the: local, regional, national or international levels. Yet many LMICs lack population and/or hospital-based cancer registries so have access to very limited cancer epidemiological data, which can lead to them making poor decisions, especially in relationship to resource allocation. For example, an LMIC may purchase an expensive and complicated high-energy linear accelerator when the bulk of the country's cancers (gynaecological cancers) could be effectively managed with a cobalt-based therapy unit, which is less expensive to purchase and maintain as well as has the ability to withstand high throughput with limited downtime (Donkor et al. 2020b; Massat 2019). The lack of epidemiological data reflects the significant challenge most LMICs encounter when describing the distribution and burden of cancer, which affect their ability to design appropriate radiotherapy services that will address the needs of most of the population.

It was revealed that LMICs' inability to define its cancer problem makes it difficult to make a strong case for government investment in establishing a radiotherapy service (Donkor et al. 2020b). Conversely, the critical role of civil society organisations, international organisations and/or agencies in improving the availability and quality of cancer registries in LMICs has been acknowledged. The 2011 Global Initiative for Cancer Registry Development led by International Agency for Research on Cancer and supported by American Cancer Society, International

Association of Cancer Registries, IAEA-Programme of Action for Cancer Therapy, UICC and Pan American Health Organisation provides opportunities to pool resources to deliver technical support and build local capacity to collect, synthesise and disseminate cancer data and findings to tackle the rising cancer burden (Bray et al. 2014; Piñeros et al. 2018).

5.4.2 Radiation safety legislative and regulatory framework

The integrated data offers new insight into the critical importance of developing a legislative and regulatory framework to ensure the radiotherapy service meets international and national radiation safety and protection standards. While developing and enforcing laws and regulations to ensure radiation safety and protection is the responsibility of LMICs' governments, it requires support from the IAEA (Donkor et al. 2020b).

All LMICs are entitled to leadership and technical support if they are IAEA members. Unfortunately, the mid-point meta-inference showed that some LMICs are not members of IAEA and have not gained the necessary recognition to establish safe and quality radiotherapy services. It also revealed that most LMICs have not been able to develop and enforce legislative and regulatory framework for the reason that the legal process and administrative tasks are complex requiring expertise and resources (Donkor et al. 2020b). These findings reaffirm the importance of the IAEA technical cooperation programme, dosimetry services to countries without dosimetry infrastructure and Quality Assurance Team for Radiation Oncology (Abdel-Wahab et al. 2017). Without these supports from the IAEA, most LMICs will not be able to establish quality and safe radiotherapy services. Hence, through continuous technical assistance, LMICs build long-term capacity to sustain and scale-up radiotherapy services.

5.4.3 Political leadership

Whilst political leadership was identified by the systematic review to be a key factor in establishing radiotherapy services in LMICs, a deeper understanding was generated through the ARC Project's mid-point meta-inference. Given the many challenges faced by LMICs, a political commitment to improving cancer outcomes was found to be central to the establishment of safe and sustainable radiotherapy services. Building support and gaining commitment requires political leadership, without which the LMIC government is unable to mobilise and allocate the necessary resources to establish a safe and sustainable radiotherapy service.

However, political conflicts, a lack of continuity of leadership, endemic bureaucratic corruption, competing demands for scarce resources and misinformation about the feasibility of radiotherapy services in LMICs all impact on clinical leaders ability to gain the commitment of the government to proceed with the establishment of safe and sustainable radiotherapy services (Donkor et al. 2020b). These factors present a significant negative impact on health services and health systems. For example, during political conflict, population movement to access

health services may be limited because of: fear of encountering military personnel; damages to health infrastructure; risk of physical or sexual assault; curfews restricting daytime and/or night-time movements; and migration of healthcare workers to protect their safety and that of their families (Sidel & Levy 2008; Zwi, Ugalde & Richards 2010). The combination of these factors diverts scarce resources away from health services in general and cancer care in particular, which in part explains why so few of the many WHO cancer policy resolutions endorsed by Member States have been implemented by LMICs (WHO 2005; WHO 2017). The historic inability of leaders to champion the expansion of radiotherapy service within their LMIC speaks to the complexity of identifying, securing and effectively managing political leaders support.

Despite these inherent challenges, it was evident that once an influential political leader commits to the development of radiotherapy, it was much more likely to be achieved. Two main political leadership facilitators for gaining commitment to establish a new radiotherapy service were identified: ministerial endorsement or approval of a radiotherapy service implementation plan; and high-profile figure been diagnosed with or dying from cancer. Ministers responsible for health are often key policy and decision-makers who are able to influence healthcare budgeting; therefore, their support often reduces political opposition to establishing a radiotherapy service (Donkor et al. 2020b). The impact of a key public figure developing cancer was also a major driver for improving local cancer care services in most LMICs, which confirms the international literature on identifying window of opportunity for securing political commitment (Frieden 2014; Hyde et al. 2002; Manyena 2013).

These findings corroborate and extend previous studies showing that political commitments can vary and lack of commitment inhibits LMICs to prioritise actions towards mobilising and allocating the necessary resources for priority interventions such as radiotherapy services to reduce cancer burden (Lingwood et al. 2008; Morhason-Bello et al. 2013; Sylla & Wild 2012). These findings contribute to new knowledge and global debates to strengthen the mechanism to foster political commitment to improve access to radiotherapy services in LMICs.

5.4.4 Awareness and advocacy

The ARC Project's mid-point meta-inference enhanced understanding about the importance of creating awareness and advocacy, and the role of local champions, who often took responsibility for ensuring that key decision-makers were better informed about the LMIC radiotherapy service gaps and the importance of acting. A public figure being diagnosed with cancer was often the impetus that political leaders needed to mobilise and allocate resources to establish a radiotherapy service, with this often occurring quite suddenly. These findings confirm the importance of creating critical consciousness about the major radiotherapy service access problems within the LMIC; and building a sense of urgency among the relevant stakeholders. In preventing HIV/AIDS transmission in most African countries, engagement of stakeholders has been noted to attract community interest and participation in and support for the project (Maher

et al. 2011; Nakibinge et al. 2009; Rasschaert et al. 2014). For example, through community group engagement, the number of women who knew their HIV status increased from 5% to 34% and that of men increased from 6% to 25% in Uganda (Nakibinge et al. 2009).

The findings also highlighted the value in continually refining and articulating the vision to establish a radiotherapy service with stakeholders, as a way of building commitment. Identifying and addressing stakeholders' expectations, fear, knowledge gaps and misconceptions that radiotherapy service implementation in LMICs is not feasible were critical to ensuring that the vision of improving cancer care through the establishment of radiotherapy services was not derailed (Donkor et al. 2018; Donkor et al. 2020b).

The availability of local champions who could articulate a clear pathway for improving cancer care outcomes within the LMIC and leverage their networks to gain direct access to and influence senior political leaders was perceived as a major facilitator by global radiotherapy experts (Donkor et al. 2020b). Other key awareness and advocacy facilitators that global radiotherapy experts acknowledged include: framing and responsibly sharing evidence-based information with a wide variety of stakeholders; frequently articulating both the economic and health benefits of establishing a radiotherapy service; and building and maintaining positive relationships with all relevant stakeholders (Donkor et al. 2018; Donkor et al. 2020b). These findings are echoed in the literature, which confirms the significance of the Global Taskforce on Radiotherapy for Cancer Control initiative that provided evidence to support awareness and advocacy by determining the: burden of cancer amenable to radiotherapy; investment needed to expand access to radiotherapy services to meet the current and future needs; financial and health benefits that will be generated from expanding access to radiotherapy services in LMICs (Atun et al. 2015).

Conversely, additional insights into several newly identified awareness and advocacy barriers to establishing new radiotherapy services have been provided, which also need to be managed. These barriers included a: perceived lack of coordination among advocates; resource constraints; local champions lack of power to convince political leaders; and negative attitude towards cancer and its treatment, particularly radiotherapy services (Donkor et al. 2020b). Managing these barriers requires an ability to harmonise the civil society organisations and/or individuals with similar priorities to prevent and reduce duplication of effort. These data suggest that lessons learned from global scale-up of HIV interventions can be applied to cancer in LMICs. At the peak of the epidemic, civil society organisations working on HIV/AIDS harmonised their activities with governments and private sector, which resulted in the establishment of HIV-specific global funding mechanisms such as the President's Emergency Plan For AIDS Relief and the Global Fund that mobilised significant funding of up to US \$500 billion over the past two decades (Zakumumpa, Bennett & Ssengooba 2019).

5.4.5 Financial resources

The integrated data confirmed several financial barriers that influence the successful establishment and maintenance of radiotherapy services in LMICs. These barriers included: prohibitive cost of the radiotherapy infrastructure; lack of comprehensive and reliable line-item budget; failure to justify the financial viability of a radiotherapy service; and inability to mobilise and allocate sufficient public and private sector funds for the establishment and maintenance of the radiotherapy service (Donkor et al. 2018; Donkor et al. 2020b). These findings also suggested that even when a radiotherapy service has been successfully implemented, it may still be inaccessible to many people with cancer because of their lack of access to universal health coverage (Donkor et al. 2018; Donkor et al. 2020b). These findings reflect the international literature which suggests that the costs associated with the use of cancer services prohibit many cancer patients from seeking care, which could be addressed through greater access to universal health coverage (World Health Organization 2019). There is a significant body of evidence that universal health coverage is feasible in LMICs if there is sustained political commitment and effective financial policies (Cazap et al. 2016; Gelband et al. 2016; Kankeu et al. 2013; Tangcharoensathien, Mills & Palu 2015).

Despite these barriers, the enhanced findings from the ARC Project's mid-point meta-inference indicate the importance of securing long-term financial commitment, which is critical to the establishment of any sustainable radiotherapy services in LMICs. It also revealed some LMICs reliance on diverse funding sources, such as: public, charity, private and/or multi-sectoral partnership financing (Donkor et al. 2018; Donkor et al. 2020b). While multi-sectoral partnerships are essential to strengthening cancer care services in LMICs, it has been suggested that these partnerships are often challenging because of the: lack of a public-private partnership legal framework; discontinuity of political leadership that creates uncertainty for the civil society or private sector partner; lack of transparency in the partnership process; and lack of pre-existing relationship with government (Frech et al. 2018; Hill et al. 2016; Suchman, Hart & Montagu 2018). The enhanced findings also emphasised the importance of acknowledging these risks and having appropriate strategies in place as part of the development of a compelling business case, as a strategy for convincing political leaders that investing in a radiotherapy service is the right thing to do (Donkor et al. 2018; Donkor et al. 2020b).

5.4.6 Project management

The ARC Project's mid-point meta-inference generated new insight into the importance of and challenges associated with the planning, coordinating and monitoring of the development of a new radiotherapy service. Numerous project management barriers were identified, including: lack of experience and well-informed strategic planning team members, especially medical physicists; inadequate stakeholder engagement; weak contract negotiations with powerful vendors, whose interests often differed significantly to those of the LMICs; and inability to

clearly define the roles and responsibilities of vendors, which contributes to their lack of accountability, especially in relationship to cost and availability of parts, maintenance plans and in-house workforce training (Donkor et al. 2020b).

The integrated data provides helpful insights into managing these barriers and the importance of harnessing the available project management facilitators, such as: creating a multidisciplinary implementation team; appointing a responsible project manager; developing a technical assistance plan; engaging with the IAEA technical cooperation programme; making appropriate arrangements for commissioning and licensing of the radiotherapy equipment; and engaging international radiotherapy workforce development volunteers (Donkor et al. 2020b). These findings highlight the crucial role of the IAEA Programme of Action for Cancer Therapy initiative, which provides cancer control project assistance through a need assessment, technical analysis, resource mobilisation, development of comprehensive cancer control plans and documents for fundraising (Enwerem-Bromson et al. 2015; Kovan 2004; Rosenblatt et al. 2012). Benefits of applying effective project management are to provide the structure and leadership required to ensure the establishment of a safe and sustainable radiotherapy service, delivered on time and budget and provides a quality outcome to people affected with cancer who require radiotherapy.

5.4.7 Radiotherapy workforce training and education

The enhanced findings provide understanding about the numerous barriers impacting on establishing a prepared and capable local radiotherapy workforce. It revealed that LMICs often overlooked the importance of building radiotherapy workforce capabilities, and the timeline for implementing education and training. Limited consideration of this crucial element and/or lack of funding allocated for the training and development of the radiotherapy workforce results in radiotherapy equipment being underutilised or used inefficiently, increasing the radiation safety risks and patients receiving treatment and poorer outcomes (Donkor et al. 2018; Donkor et al. 2020b). Failure to plan and prepare the radiotherapy workforce, meant that other healthcare professionals, such as nurses, were in some LMICs being asked with little or no training to administer radiotherapy. This sophisticated and specialised field of cancer treatment is outside the nursing scope of practice and place both the nurse and cancer patient in a high-risk situation. Alternatively, the radiotherapy facility would lay idle, for lack of a prepared workforce or dependant on overseas experts to be able to operate the radiotherapy equipment in the short-term.

While medical physicists are vital for quality assurance and radiotherapy equipment maintenance, other studies have suggested that they are not recognised as health professionals in most LMICs and therefore are not supported (Barton, Zubizarreta & Gospodarowicz 2017; Zaidi 2008). As a result, many medical physicists and other radiotherapy workforce have migrated to find attractive working conditions in HICs (Donkor et al. 2020b).

Other studies have shown that the migration of skilled health workforce is often harmful to LMICs because it creates shortages in the health sector (Addis 2014).

On the other hand, the enhanced findings provide understanding about the importance of collaborative training and educational mechanisms that help bridge the gaps in radiotherapy workforce. Such collaborative training and educational programmes often provide peer-to-peer support, information sharing and hands-on in-country fellowships (Donkor et al. 2018; Donkor et al. 2020b). There have been international initiatives devoted to building the radiotherapy workforce through education and training, such as those supported by the IAEA, UICC, Radiating Hope, Asia-Pacific Radiation Oncology Special Interest Group of the Royal Australian and New Zealand College of Radiologists and American Cancer Society (Collins, Burn & Ritman 2015; Einck et al. 2014; Ngwa & Ngoma 2016; Union for International Cancer Control 2020a). Such initiatives have focussed on continuing professional development and technical fellowships and have contributed to developing over 4,000 cancer care professionals from over 110 countries, including radiation oncologists who are focussed on providing high quality and safe radiotherapy services (Union for International Cancer Control 2020b).

It was highlighted and enhanced that equipping radiotherapy workforce with updated clinical guidelines and protocols was important. It was also suggested that developing and embedding a plan to ensure regular review and update of guidelines and protocols on the basis of new scientific information and clinical experience was essential to ensuring that the radiotherapy workforce in LMICs was able to provide optimal cancer care (Donkor et al. 2020b). This is an important finding since initiatives are emerging to develop relevant clinical guidelines that are appropriate for use in LMICs. The African Cancer Coalition is an example of such initiative, which consists of a consortium of oncology experts in Africa working with the National Comprehensive Cancer Network, International Business Machines Corporation, American Cancer Society and Clinton Health Access Initiative to develop standard cancer treatment guidelines for use in Africa (Niyonzima 2018). The challenge as always with guidelines is to ensure their reliability, currency and completeness, which are important factors to consider from the outset.

5.4.8 Basic physical infrastructure

The ARC Project's mid-point meta-inference confirmed the significance of access to adequate quality physical infrastructure when establishing safe and sustainable radiotherapy services in LMICs. Major basic physical infrastructure barriers identified include: lack of reliable supply of electricity and water; and poor road network that can constraint cancer patients' ability to access radiotherapy services (Donkor et al. 2018; Donkor et al. 2020b). It also revealed how a lack of water and/or intermittent power supply damages expensive radiotherapy equipment, which was very costly to repair. This is not an unexpected finding because inadequate supply of water and electricity to healthcare facilities in most LMICs have been reported in the literature (Prüss-

Ustün et al. 2014; Suhlrie et al. 2018). However, the importance of addressing these gaps has been acknowledged in a number of global policy documents (Franco et al. 2017; Watts et al. 2018). The Advisory Group on increasing access to Radiotherapy Technology in LMICs initiative launched by the Programme of Action for Cancer Therapy of IAEA is responding to these challenges. This group has brought radiotherapy manufacturers, vendors, international organisations and regional experts together to develop affordable, suitable and sustainable radiotherapy systems that are tailored to the contextual conditions of each LMICs (International Atomic Energy Agency 2013; Samiei 2013).

Despite these significant barriers, the enhanced findings provided greater understanding about basic physical infrastructure facilitators that ensure cancer patients have the opportunity to utilise radiotherapy services (Donkor et al. 2018; Donkor et al. 2020b). Additionally, developing and implementing cancer patient assistance programmes such as accommodation, transportation and/or financial assistance are designed to enable more cancer patients to access radiotherapy services and at a reasonable cost (Donkor et al. 2018; Donkor et al. 2020b). Encouragingly, many LMICs have moved to address these infrastructure issues. For example, in several Latin American countries have implemented collaborative cancer care initiatives designed to provide services such as: hostel accommodation for cancer patients and a family member who live some distance from the treatment facility; daily transportation for patients who have difficulty accessing public transportation; and schooling for children diagnosed with cancer to ensure they continue their education during treatment (Epelman & Magrath 2013; International Network for Cancer Treatment and Research 2015; Magrath et al. 2013; NCD Alliance 2011). While data for measuring impacts of these programmes could not be identified, it is highly possible that generally more people with cancer have better access to and completion of cancer treatment, including radiotherapy services.

5.4.9 Governance and management structure

The ARC Project's mid-point meta-inference also provided new insights into the crucial role of developing a multidisciplinary governance and management board to ensure clinical and non-clinical accountability, coalition building, regulation and incentive enforcement. It was revealed that the governance and management board of the local radiotherapy centre has the responsibility for developing and implementing financial strategies, service contract and maintenance policies that promote quality, safe and sustainable radiotherapy service delivery (Donkor et al. 2020b). Studies from HICs confirm that well-managed radiotherapy services produce better clinical outcomes and higher cancer patient satisfaction (Blackman et al. 2018; Brown 2019; Hughes et al. 2015).

In contrast, helpful insights into the barriers of governing and managing radiotherapy centres in LMICs were provided. When the duration and term of office for the management board members were unspecified, the risk of lack of transparency and accountability was much

greater (Donkor et al. 2020a, 2020b). There is evidence that shows governance and management board members often have the tendency to abuse their power in the absence of democracy and respect (Mitchell & Shortell 2000; Okpara 2011; Pirson & Turnbull 2011). Additionally, the confirmatory findings indicate that high cost of spare parts, lack of qualified engineers, inadequate support from vendors and lack of dedicated funding are major maintenance barriers that radiotherapy service governance and management board usually encounter in most LMICs (Donkor et al. 2018; Donkor et al. 2020b).

5.4.10 Information and communication technologies

The confirmatory findings indicates that information and communication technologies promote coordination and continuity of cancer care by aiding exchange of information among cancer care teams as well as between cancer patients and their care providers (Donkor et al. 2018; Donkor et al. 2020b). It also confirmed that information and communication technologies facilitated LMICs cancer specialists being able to regularly connect with their global peers. The importance of fostering peer support and learning opportunities is reflected in recent initiatives undertaken by the IAEA Virtual University for Cancer Control, Chartrounds and Africa Radiation Oncology Network, which are helping bridge the knowledge gap in cancer care workforce through information and communication technologies capabilities (Ngwa et al. 2016; Ngwa et al. 2015; Rosenblatt et al. 2018). Access to video-conferencing and online learning resources provides LMICs cancer specialists with an opportunity to enhance their knowledge, discuss and review challenging cancer cases. For instance, the Africa Radiation Oncology Network has helped cancer centres in 14 African countries over five years (2012-17) to participate in: 64 monthly online discussions; and 154 cancer cases have been discussed by a group of radiation oncologists to reach management consensus (Rosenblatt et al. 2018).

Investing wisely in hospital integrated information support systems is critical to radiotherapy, as it enables services to capture all activities and patient care, including: pathology, radiology, laboratory tests, treatment planning decisions, prescriptions and payments (Donkor et al. 2018; Donkor et al. 2020b). Furthermore, the confirmatory findings highlight the critical role of reliable internet access and digital communication platforms, which enable cancer patients and specialists to access timely information in an efficient manner (Donkor et al. 2018; Donkor et al. 2020b).

In spite of the tremendous opportunities that information and communication technologies offer LMICs, it confirmed that a lack of communication pathways and coordination between cancer specialists resulted in sub-optimal planning and treatment for many cancer patients (Donkor et al. 2018; Donkor et al. 2020b). Inadequate communication and poor coordination between cancer specialists is also a problem reported in the literature from high-income countries (HICs). Adverse effects of communication barriers on cancer patients include misunderstanding, time-consuming process, confusion and frustration, which negatively impact cancer treatment

outcomes (Easley et al. 2016; Walsh et al. 2010). The nature of these challenges are however amplified in LMICs, where health systems are often more fragmented. The finding also confirmed the lack of training and assistance for information technology staff to accomplished effective data collection, analysis and dissemination of clinical and non-clinical information (Donkor et al. 2018; Donkor et al. 2020b).

5.4.11 Research collaboration

The confirmatory findings from the ARC Project's mid-point meta-inference indicate the essential role of developing international and/or regional collaborations to build both research capacity and radiotherapy expertise for the establishment of safe and sustainable radiotherapy services. Building international and regional research collaborations often impacts on LMICs ability to access up-to-date evidence-based guidelines while being supported/mentored into adopting them into local radiotherapy practice. Identifying research funding sources, promoting interest in evidence-based practice, retaining a trustworthy relationship and availability of information technology resources were critical to ensuring that research collaboration was sustained (Donkor et al. 2018; Donkor et al. 2020b). These findings are reflected in the literature where initiatives such as Cancer Expert Corps have started providing opportunities for HIC partners to maintain research, education and training collaborations with their international partners to improve cancer care in LMICs by ensuring treatment efficacy, safe treatment for patients and suitable working environment and conditions for staff (Coleman et al. 2014; Coleman et al. 2017).

Table 5.1: Joint display table representing data integration, convergence and inference for Research Question Two

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?				
	Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
Barriers	The systematic review identified multiple barriers that impact on LMICs capacity to establish and maintain radiotherapy services, including	The participants' numerous barriers that impact on LMICs ability to establish radiotherapy services, including		
	Financial constraints usually affected investment decision for the establishment of a radiotherapy service	Difficulties in mobilising/allocating financial resources <i>"...it is very difficult because we are depending on government grants." (P16, CO, Local).</i>	Confirm	Securing a reliable and affordable source of financing for the establishment of a radiotherapy service (i.e. equipment purchase, radiotherapy workforce training and operational maintenance) in LMIC is challenging. Financing arrangements influence the way radiotherapy services are configured and have long term implications for service viability and access.
	Equipment maintenance difficulties and/or periodic equipment breakdown	Lack of long-term affordable contract, poor supply of spare parts and costly maintenance /spare parts costs <i>"...all these machines are coded in American dollars...our currency is not very good right now...So, they say, 'Okay, we don't want the machine anymore because you're giving the machine you are not giving money for the next five years to maintain the machine' (P13, RO, Local).</i>	Confirm	The maintenance of radiotherapy equipment is complex, expensive and dependent upon the timely input of medical physicists, local engineers and the vendor. Despite this complexity, if maintenance is not planned for, LMICs can be left without a functional radiotherapy service as a result of poor technical and clinical equipment support.
	Poor road network to the radiotherapy centre	Lack of appropriate transport system	Confirm	Basic infrastructure such as road, transport, consistent supply of electricity and water are critical

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
	<i>"In some cases, patients have to travel about five hours to the radiotherapy centre daily for treatment"</i> (P13, RO, Local).		factors in terms of sustaining the radiotherapy service and cancer patients' ability to access the radiotherapy service.
Lack of universal health coverage that limits cancer patients' access to radiotherapy services	Financial hardship to patients and their families because of the absence of universal health coverage	Confirm	A lack of universal health coverage limits cancer patients' timely access to radiotherapy services due to high cancer treatment costs.
Lack of political commitment was identified as a primary reason for the low priority that radiotherapy service receives from governments	Lack of leadership continuity <i>"...the most challenging things are politics, our politicians...they change every three or four years depending on the country. So, it's very difficult to have continuity of investment"</i> (P13, RO, Local).	Enhance	Given the many challenges faced by LMICs, a political commitment to improving cancer outcomes is central to the establishment of local radiotherapy services. A political commitment is necessary for mobilising and allocating resources to achieve the common radiotherapy service goal. The lack of political leadership, continuity and commitment obscure accountability and affect decision making.
Shortage of human resources, which was found to impact negatively on patient safety and quality of radiotherapy service delivery	Lack of a suitably trained radiotherapy workforce <i>"In one case...the facility was ready, the equipment was installed, but the trainees were not ready...and what happened during that time, rats and mice basically ate up the wiring"</i> (P3, RO, International).	Enhance	LMICs often overlook the importance of radiotherapy workforce training and education and the time it takes to prepare the workforce. Limited investment in radiotherapy workforce education and clinical training infrastructure, results in radiotherapy equipment being underutilised or used inefficiently,

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
	The participants also identified barriers that were not evident in the systematic review, including:		increasing radiation safety risks and patients receiving sub-optimal treatment and poorer outcomes.
The consequence of lack of epidemiological data not described in the literature	Lack of epidemiological data <i>"The starting point is the demographics, which again may or may not be available in some countries...in many cases, the data were extrapolated, especially in Africa because there are so few countries with good cancer registries" (P3, RO, International).</i>	New	Most LMICs do not have population-based and/or hospital-based cancer registries. The lack of accurate epidemiological data makes it challenging to describe the LMICs burden of cancer, and epidemiological profile and to design a radiotherapy service that will address the needs of most of the population. A countries inability to define its cancer problem makes it difficult to make a strong case for investing in establishing a radiotherapy service.
The consequence of poor stakeholder engagement was not identified in the literature	Poor stakeholder engagement <i>"...the medical physicists were not involved, right from the beginning...when the companies came to evaluate the status of the bunkers, they found some design problems" (P10, CO, Local).</i>	New	Engaging individuals who have clinical and technical knowledge of radiation safety requirements and processes involved in establishing a radiotherapy service is often ignored with occasionally serious implementation consequences.

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

	Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
	The consequence of poor contract management/absence of clear responsibilities for vendor was not identified in the literature	Poor contract management/absence of clear responsibilities for vendor <i>"The machines will be sold, but there's not any kind of responsibility...to see it through to the end. It's just like, "Okay. we've sold it. That's it". (P1, RO, International).</i>	New	Given the lack of experience and technical expertise in radiotherapy in most LMICs, developing an effective contract with clear vendor's role and responsibilities presents an enormous challenge. The lack of a clear role and responsibilities indicates that most LMICs do not receive adequate response and support from vendors after equipment purchase.
Facilitators	The systematic review also found several facilitators that enabled LMICs to establish and maintain radiotherapy services, including	The participants identified various facilitators that supported LMICs to establish radiotherapy services and include a		
	Academic health institutions research collaboration that supports knowledge sharing	International and/or regional research collaboration <i>"...they should really link with very good regional and international radiotherapy centres to learn and research" (P7, CO, Local).</i>	Confirm	International and regional collaborations are seen as essential to building both research capacity and radiotherapy expertise. Building international and regional research collaborations often impacts on LMICs ability to access up-to-date evidence-based guidelines and being supported/mentored into adopting them into local radiotherapy practice.
	Supportive technology that is necessary to coordinate care	Information and communication technologies in support of cancer care <i>"We are connecting everybody digitally so that people can network, conference and move</i>	Confirm	Exchange of information among cancer care teams as well as between patients and their cancer care providers is critical. Reliable

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
	<i>ahead...specialists can connect with each other" (P11, RO, Local).</i>		internet access and digital communication platforms enables cancer specialists, including radiation oncologists to connect regularly with their peers in other countries.
Strong political commitment was found to be crucial for mobilising resources	Strong political support <i>"...with the support of the Ministry of Health...six centres and teaching hospitals were selected to start cancer care, including radiotherapy" (P10, CO, Local).</i>	Enhance	The ministry responsible for health often approves policies for enhancing cancer care, including radiotherapy services. Establishing a radiotherapy service is, therefore, highly dependent on the ministry responsible for health support and political will to allocate funding.
Financial support from government, private sector and/or non-profit sector facilitated the establishment of the radiotherapy service	Diversified sources of funding <i>"...there is government and private corporation money that's gone into setting up the facility...the difference is the patients will pay for their radiation therapy services" (P6, RT, International).</i>	Enhance	It is often considered necessary to secure funding from multiple sources to establish and maintain a radiotherapy service because funds are limited in most LMICs. Limited funds means that the delivery of basic health care is given first priority. Diversifying funding sources ensures the operational and financial sustainability of the radiotherapy service is not dependent on one funding source and therefore not vulnerable.

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
Availability of vision champions to lead awareness and advocacy actions such as lobbying political leaders	Vision champions for advocacy/useful window of opportunity <i>"[You need] someone that has some sort of clout...that will listen to...a university professor, or physician, or a senior medical physicist, or even someone that works in the government already" (P4, MP, International).</i> <i>"...there is a VIP element that often crops up...now there are no resources, and then the First lady gets breast cancer...and suddenly these resources appear...often these VIPs would travel to Europe or North America for treatment and then they would come back and say, "We want all the bells and whistles that we saw" (P3, RO, International).</i>	Enhance	Vision champions help to advocate and create awareness. Through advocacy and awareness, decision-makers are often better informed to respond to the radiotherapy service gaps. A public figure being diagnosed with cancer often provided the opportunity for political leaders to suddenly mobilise and allocate resources to establish a radiotherapy service in most LMICs.
Adherence to evidence-based practice to promote quality radiotherapy outcomes	Adoption of evidence-based practice <i>"We use guidelines and sit every year to review these guidelines. We put the guidelines under discussions" (P7, RO, Local).</i>	Enhance	Some LMICs have adopted evidence-based practice approach for delivering quality radiotherapy services for cancer patients. However, global radiotherapy experts indicated that there ought to be a plan to regularly update clinical guidelines based on scientific new evidence and clinical experience.

The participants also identified facilitators that were not evident in the systematic review, including:

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
The consequence of integrated country-wide cancer control policy was not identified in the literature.	Availability of an integrated country-wide cancer control plan <i>"...you need the cancers that are preventable being prevented. You need early detection so that the cases that are coming into radiotherapy are maximised...Then you're palliating the ones that can be palliated" (P15, RT, International).)</i>	New	Developing an integrated country-wide cancer control plan is often regarded as an approach to reduce the burden of cancer by setting out the vision and key directions for prevention, early detection, diagnosis, treatment, survivorship and end-of-life.
The consequence of legislative framework/membership with IAEA was not identified in the literature.	Availability of a legislative framework/established membership with IAEA <i>"...countries have to apply for membership in the IAEA...as part of membership, they may have a modest fee...but then they are also required to have some legislation in place for accountability of the radioactive materials" (P3, RO, International).</i>	New	Developing a radiation safety laws and regulations is often seen as the responsibility of the LMICs. However, establishing membership with the IAEA created opportunities for LMICs to receive support and develop a country-wide radiation safety infrastructure that meets the international safety standards to ensure radiation safety both now and in the future.
The consequence of appointing responsible project manager was not identified in the literature	Appointment of responsible project manager <i>"We learned the hard way that all the coordination of all these activities, somebody has to stay on top of it. So we just insisted that this planning had to be made, a timeline had to be made, there had to be a project manager in charge who was orchestrating these various moving parts so that when the facility was ready the staff were ready" (P3, RO, 70 years)</i>	New	The planning, coordinating and monitoring of a radiotherapy service implementation activities can be challenging. Appointing an experienced project manager with technical and contextual knowledge to develop timelines and coordinate the implementation activities helps establish the radiotherapy service

Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

Findings from Study One (systematic review)	Qualitative data from Study Two [Part A] (semi-structured interviews)	Data convergence	Mid-point meta-inference
			within budget, on time and with high-quality outcome.
The consequence of inclusive governance and management board was not identified in the literature	Availability of inclusive governance and management board <i>"The cancer hospital is run by 9-member management committee...These board members are responsible for the development... and all the financial aspect...of the hospital... they have a certain time frame" (P14, Administrator, Local).</i>	New	A multidisciplinary governance and management board approach is essential to ensure clinical and non-clinical accountability, coalition building, regulation and incentive enforcement.
The consequence of multidisciplinary team (MDT) was not identified in the literature	Availability of MDT <i>"We created the [multidisciplinary] team and we used to meet once a week to discuss only new cases after workup, and after doing the staging, and then to put the plan into action... no patient can be treated without having decision by the multidisciplinary team" (P7, RO, Local).</i>	New	MDT is often created to diagnose, plan and treat cancer patients with the goal of delivering the best quality of care. Regularly MDT meeting and communication to all members of the team ensures that the patient's cancer care is agreed upon at the outset of treatment.

Legend: Confirm – the current study reinforces the findings of the previous study; Enhance – the current study further improve the findings of the previous study; New – the current study provides findings not existing before in the previous study

Summary

The mid-point meta-inference has illustrated the complex interplay of facilitators and barriers that impact on LMICs abilities to establish a sustainable and safe radiotherapy service(s). It is important for LMICs at the outset of planning a new radiotherapy service to prioritise and consider multiple factors including, such as: an analysis of the cancer epidemiological data to identify the most common types of cancers locally; radiation safety legislative and regulatory framework; political commitment; funding; training and education for radiotherapy workforce; spare parts; consistent supply of electricity and water; information systems; and research collaboration.

Given this complexity, and the fact that there are so many factors to consider, assessing LMICs' readiness to proceed would seem to be an important consideration, prior to investing in such a major infrastructure development project. The mid-point meta-inference has identified a number of key requirements that LMICs could potentially use to appraise their capacity to proceed with developing a new radiotherapy service. Ensuring these pre-requisites are in place would appear to be essential for establishing safe and sustainable radiotherapy services. They also would assist LMICs with the appropriate sequencing of activities to ensure that they have mobilised the necessary resources at critical junctures to prevent delays and unnecessary planning errors, which previously have resulted in significant waste and increased project costs.

While over the past six decades the IAEA has developed a variety of technical and dosimetry measurement tools to facilitate safety, quality assurance, commissioning and staffing of radiotherapy services, they are focused on the technical aspects of establishing a radiotherapy service (IAEA 2014, 2015). The IAEA suite of master planning tools assist with the detailed design of the radiotherapy facility by specifying the clinical, medical physics, radiation protection and safety standards (IAEA 2006, 2008, 2014). These planning tools are technically complex and difficult to use by stakeholders with no prior experience of establishing and sustaining a radiotherapy service, which is the case for many LMICs.

To address this need, a group of international researchers have developed a '10-Step Framework' for use by LMICs to help normalise the implementation process of new radiotherapy equipment and technologies, but not the broader planning process (Brown et al. 2014). This unvalidated tool assists LMICs to consider: site and resource assessment; evaluation of equipment and funding; establishing timelines; defining the treatment process; equipment quality assurance and commissioning; training and competency assessment; prospective risk analysis; system testing; external audit; and follow-up support (Brown et al. 2014). However, this Framework is not broad enough to cover the necessary critical success factors to enable effective establishment of a new radiotherapy service in LMICs. The methodology underpinning the development of this tool is not described, but appears to be based on the collective expertise of the authors (Brown et al. 2014).

Although many LMICs might be willing to establish safe and sustainable radiotherapy services, they lack access to rigorous and systematic guidance, other than the '10-Step Framework, developed by Brown and colleagues, which focuses exclusively on the technical aspects of implementing a new radiotherapy technology (Brown et al. 2014). Developing a comprehensive list of requirements and criteria, generated through consultation with global radiotherapy experts, was considered necessary to provide practical guidance to LMICs seeking to establish safe and sustainable radiotherapy services.

5.5 Alignment between need and readiness assessment

The next section presents a summary of needs and readiness assessments approaches that have been used by different countries and/or service planners to help determine the feasibility and attainability of developing a new health service or programme. The aspects of these readiness assessment approaches that are considered to be relevant to the planning of a new radiotherapy service are presented.

5.5.1 Defining 'need'

A 'need' implies that there is a gap between the current condition and the ideal condition (Owen & Rogers 2006). The importance of better understanding 'needs' has long been acknowledged by a number of theorists (e.g. Bradshaw 1970). Four types of 'needs' have been described in the planning and evaluation literature, namely: expressed need; normative need; felt need; and comparative need (Royse, Thyer & Padgett 2016). Expressed need is what people have acted on. Expressed need is manifested as the demand for services, which is when 'need' turned into action. Normative need is the 'need' defined by experts or professionals according to scientific standards. Felt need is the 'need' people feel; it includes what they want and their preferences. Comparative need is the recognised gap between advantage and disadvantage population. The disadvantage population are defined as being in 'need' (Royse, Thyer & Padgett 2016).

5.5.2 What is a need assessment?

A need assessment is a systematic planning process intended to: define a population's health service needs; evaluate existing health service capacity; determine health service utilisation patterns; and determine which health issues should be prioritised for action (Gilmore 2011; Hodges & Videto 2011; Stevens & Raftery 2018). A need assessment is a component of programme evaluation because it involves gathering information to make an evaluative decision about what gaps exist in a country (Royse, Thyer & Padgett 2016).

The typical need assessment is configured to identify gaps that need to be addressed (Dearing 2018; Eldredge et al. 2016) and to ensure that systems and structures are in place to promote and support effective decision-making, planning and operationalisation (Stevens & Raftery 2018; Weiner 2009). There is no one right way to conduct a need assessment. However, four

models have commonly been used, including the: epidemiological model; public health model; social model; and asset model (Bhandari, Hunter & Phillips 2013; Issel & Wells 2014, 2017).

Epidemiological model. Adopting an epidemiological a need assessment model was not relevant to the ARC Project because it focuses on quantifying health issues by using existing national databases and applying epidemiological methods and statistics (Issel & Wells 2014, 2017; Stevens & Raftery 2018). An epidemiological a need assessment model usually focuses on identifying risks and hazards of health problems (Issel & Wells 2014); and seeks to answer questions, such as: What is the magnitude of the health problem? What is the pattern of distribution of the health problem? How preventable and treatable is the health problem? What is currently being done about the health problem? Epidemiological model to a need assessment provides data that highlights the seriousness, importance and prevalence of the health problem (Issel & Wells 2017).

Public health model. A public health a need assessment model did not align with the ARC Project because it relies on existing epidemiological data for the purpose of prioritising the identified health problems and investing wisely with the limited resources (Issel & Wells 2017). Tools used in the public health model to a need assessment include Precede-Proceed, Multilevel Approach to Community Health, Planned Approach to Community Health and Mobilizing for Action through Planning and Partnerships (Issel & Wells 2017). The public health model to a need assessment seeks to answer questions, such as: What is the seriousness of the health problem? What is the distribution of the health problem? What is the perceived importance of the health problem? What resources are available to address the health problem? (Issel & Wells 2017).

Social model. The social model to a need assessment focuses on collecting data regarding socioeconomic and political factors that affect the health of individuals (Issel & Wells 2017), which was deemed not to be the focus of the ARC Project. The social model to a need assessment seeks to answer the questions: What is the relationship among health problems and social characteristics? How have social and health policies affected the distribution or trends of the health problem? The social model to a need assessment generates vital information that could help identify determinants of the health problem (Issel & Wells 2017).

Asset model. The asset model to a need assessment focuses on the abilities, strengths, assets and resources that are available rather than focusing on the gaps between the healthy and the unhealthy (Issel & Wells 2017). The asset model to a need assessment was partially relevant to the ARC Project because it helps understand the country's capacity. Capacity such as human and financial resources have been explained by the two conceptual frameworks underpinning the ARC Project (see Chapter One). The asset model to needs assessment seeks to answer the questions: What social and health resources exist within the country or community experiencing the health problem? What do individuals view as strengths and resources within

the country or community? and To what extents are resources mobilised to address health problems? Generating asset data can be challenging because there is no generally accepted set of asset indicators that can be used (Issel & Wells 2017). While the asset model helps map concentrates on mapping

Planners often conduct a need assessment as a critical first step in understanding the health issue in the country or community (Wambeam 2015). The information generated through a need assessment is important to gain an in-depth understanding of how the country ought to focus its attention (Stevens & Raferty 2018).

One conclusion that can be drawn from the available evidence on a need assessment is that meaningful data collection is essential. Data is critical to ensure that a need assessment outcome is based on factual information (Petersen & Alexander 2001). Countries have a responsibility to gather accurate and reliable data to enable evidence-informed decision making for planning, policy development, health programme implementation, monitoring and evaluation.

Ideally, when LMICs are setting out to establish a new radiotherapy service, a need assessment can be used to confirm the target populations in need of the service, as well as identify new target populations with unmet radiotherapy service needs. LMICs can, therefore, use a need assessment to define and refine their radiotherapy service development goals, objectives and implementation activities. Given these purposes, a need assessment plays a crucial role in radiotherapy service strategic planning and development efforts in LMICs.

5.5.3 Moving from ‘need’ to ‘readiness’ for action

While a need assessment provides baseline data to understand and prioritise pressing challenges, it does not determine the country’s or community’s capacity, interest and support to implement the necessary solution (Wambeam 2015). Moving beyond the process of assessing needs to determining the country’s readiness to develop, implement, sustain and scale-up solution strategies is a crucial step for addressing identified gaps (Altschuld & Witkin 2000). Once a need has been established, it is easier to move towards developing a targeted strategy to address the identified gaps and mobilise the necessary funds to address the health concerns.

A readiness assessment in many respects acts as a bridge from a need assessment to action. A readiness assessment ideally should not be done without a detailed understanding of the country’s needs. Thus, a readiness assessment takes place after ‘needs’ have been identified and prioritised through a need assessment (Eldredge et al. 2016; Tones & Green 2015). Readiness consists of defining requirements for solution strategies, exploring alternative solutions based on the ‘needs’, and understanding the capacity to select and implement the strategy that has the potential of resolving the need (Altschuld & Witkin 2000; Eldredge et al. 2016; Tones & Green 2015).

5.5.4 What is a readiness assessment?

'Readiness' is the capacity of a country to develop, implement, sustain and scale-up health programmes and policies to improve health service (Weiner 2009). 'Readiness' consists of several dimensions, including: the country's recognition of the health problem; senior political leaders support and commitment; a clear vision to address the health concern; and the availability of the necessary resources (DiClemente, Schlundt & Gemmell 2004; Timmings et al. 2016). Conducting a readiness assessment for a health programme is a collective and an ongoing endeavour.

A readiness assessment provides the opportunity to address barriers identified either before or as part of the implementation process (Eldredge et al. 2016; Tones & Green 2015). Thus, readiness assessment can save money and time. A readiness assessment often gathers data that help evaluate leadership support, stakeholders' expectations and concerns, project management capabilities and organisation of healthcare workforce (PATH 2019; Sarran, Clark & Mendonca 2011). Similarly, a readiness assessment examines how decisions are made in a country/organisation and provides an opportunity to determine available resources, critical areas that need improvement and how the government vision aligns with the healthcare initiative (Ajami et al. 2011; Biruk et al. 2014).

5.5.5 Sources of readiness data

A readiness assessment often requires multiple data sources including qualitative and/or quantitative measures (Biruk et al. 2014). This is because a readiness assessment seeks to answer multiple questions from various perspectives. Hence, different methods have been used to assess readiness, including surveys, focus groups, telephone or face-to-face interviews with key stakeholders within the country, community or organisation, and analysing stories in the local media (Al-Solbi & Mayhew 2005; Sawicki et al. 2009; van Staa et al. 2011).

5.5.6 Identifying and building readiness

There are a large number of different readiness assessment tools available for use and adaption across healthcare for identifying and building readiness as summarised in Table 5.2. The various readiness assessment tools lend themselves for use with different projects and all vary in their dimensions and in the readiness requirements they measure.

Despite these differences, there are some common elements across the readiness assessment tools. Most of the readiness assessment tools indicate that stakeholder engagement can help identify the leadership and support needed to address health issues (DiClemente, Schlundt & Gemmell 2004; PATH 2019). For example, while the Readiness Assessment Toolkit for Establishing and Integrating Human Milk Bank Programmes is not deemed fit to appraise LMICs' readiness to establish safe and sustainable radiotherapy services, it suggests that

engaging stakeholders enhances buy-in for the proposed initiative and helps to identify who has the appropriate authority to serve as the champion for the programme (PATH 2019).

The majority of the available readiness assessment tools evaluate a country's or organisation's capacity to undertake change (Gholamhosseini & Ayatollahi 2017; Hirschhorn et al. 2007; Otoo, Agapitova & Behrens 2009). These country-level readiness assessment tools acknowledge that readiness is a function of both external and internal factors, which are crucial when establishing safe and sustainable radiotherapy services in LMICs. The internal factors that affect readiness include: human resources; political support; financial resources; and governance and management, while the external factors that influence readiness include: technical assistance; government policy/political environment; legal and regulatory framework; and socio-cultural and geographic environment (Dearing 2018).

The readiness assessment tools, such as Management and Organizational Stability Tool and Change Management Toolkit also indicate how much effort is required to create good governance and management to address needs that are important (Sarran, Clark & Mendonca 2011; Vriesendorp 2004). Done properly, good governance and prudent management can have positive influence on strategic planning and appropriate mobilisation and allocation of resources to address a particular issue (Vriesendorp 2004). Again, the Management and Organisational Stability Tool is deemed not to focus on assessing LMICs' readiness to establish safe and sustainable radiotherapy services, however, it establishes a participatory mechanism that enables a rapid-assessment process for identifying an organisation's management needs and making concrete plans for improvement (Vriesendorp 2004). This Tool casts a broad net, encompassing organisation's mission, values, strategy, structure and systems for planning, communication, human resource management, financial management, monitoring and evaluation, information management, quality assurance and revenue generation and supply management (Vriesendorp 2004).

Just as understanding the legal and policy support of a country is central to effective programme planning, the Capacity Building in Training-Dimensions and Indicators acknowledge that it is equally important to understand the technical capability and extend to which the country would be interested in participating in a relevant community development programme (Fort 1999). These are requirements that are essential when establishing a new radiotherapy service to ensure that there is knowledge and expertise for quality and safe delivery of radiotherapy services.

Whereas the Capacity Development Results Framework (Otoo, Agapitova & Behrens 2009) and the Discussion-Oriented Organisational Self-Assessment Tool (Levinger & Bloom 1997) are not relevant for appraising LMICs' readiness to establish a new radiotherapy service, they acknowledge the crucial role of providing structures for gathering information with the goal of facilitating resources, harnessing political commitment and building internal capacity. Political

leadership and commitment are crucial requirements for garnering the necessary resources for the establishment of a new radiotherapy service in LMICs (Donkor et al. 2020b).

5.5.7 Lessons identified from existing readiness assessment tools

While the literature is awash with several readiness assessment tools (PATH 2019; Sarran, Clark & Mendonca 2011; Vriesendorp 2004), the ARC Project's mid-point meta-inference did not identify any readiness assessment tool that is obviously relevant for appraising LMICs progress and structures to establish safe and sustainable radiotherapy services. However, it must be noted that there is a substantial number of requirements that are relevant to the planning of a new radiotherapy service in LMICs. Extrapolating from the identified readiness assessment tools, lessons learned that will be most applicable to radiotherapy service include the following:

- create and align a shared vision and common purpose towards the desired radiotherapy service development goals;
- focus on securing and maintaining political commitment to ensure the mobilisation and allocation of the necessary resources to establish a new radiotherapy service;
- identify a local champion who will assume a leadership role, such as advocacy, coordination and collaboration to influence senior political leaderships;
- draw upon the technical experiences, skills and knowledge of international organisations to plan, design, implement and sustain the radiotherapy service;
- develop an ongoing budgetary plan to support the establishment and maintenance of a new radiotherapy service;
- draw on the importance of information communication technologies to support the coordination of cancer care;
- focus on developing multi-sectoral partnerships to mobilise the necessary resources to establish and sustain the radiotherapy service;
- assess training and educational requirements of radiotherapy workforce to ensure quality and safe delivery of radiotherapy services; and
- integrate governance and management structure to ensure transparency and accountability

Table 5.2: Examples of readiness assessment tools

Tool name	Core components relevant to developing a new radiotherapy service in LMICs
Readiness Assessment Toolkit for Establishing and Integrating Human Milk Bank Programmes (PATH 2019)	• Assessing the level of local leadership commitment and support to address an unmet need • Identifying the existing relevant government policies to address an unmet need • Assessing the training requirements for staff to ensure safety and quality • Assessing set-up costs and ongoing budgetary support for programme • Identifying essential infrastructure, space and equipment requirements • Building a network of local, regional and national support organisations
'Ready, Set, Change' Readiness Support Tool (Timmings et al. 2016)	• Assessing the healthcare organization capacity to implement change • Recognising the role of effective teamwork to implement change • Identifying the role of information technology to support change
Organizational readiness for change (Weiner 2009)	• Assessing leaders' commitment to implement change • Assessing past experience and team effort to implement change • Identifying existing policies and procedures to support change • Identifying organisations structures and resources to implement change
e-health Readiness Assessment Tool (Gholamhosseini & Ayatollahi 2017)	• Assessing the healthcare organisation's awareness of e-health • Assessing the healthcare organisation's access to the internet • Assessing the training needs of the staff
Readiness Assessment Toolkit for Diagnostic Imaging Peer Learning (Health Quality Ontario 2019)	• Assessing the learning and educational system of the healthcare organisation • Identifying the governance and accountability structure of the healthcare organisation • Assessing the training needs of stakeholders

	Identifying resources to monitor and sustain the programme
Capacity Building in Training-Dimensions and Indicators (Fort 1999)	- Identifying the legal and policy support to address unmet needs - Assessing the available resources (financial, equipment and venues and human) to implement the programme - Developing training plans and curriculum for staff - Identifying technical capability and assistance to implement the programme - Community development and participation – involvement of community representatives
Capacity Development Results Framework (Otoo, Agapitova & Behrens 2009)	- Assessing available financial, human and technological resources to address unmet needs - Engaging stakeholders to ensure local ownership of programme
Discussion-Oriented Organisational Self-Assessment (Levinger & Bloom 1997)	Identifying technical skills and human resources to develop and implement the programme
Management and Organizational Stability Tool (Vriesendorp 2004)	- Assessing the skills and knowledge to address the unmet needs - Identifying the available strategy to address the unmet needs - Assessing structures to ensure accountability, governance and decision-making
Tool to Assess Site Readiness for Initiating Antiretroviral Therapy (ART) or Capacities for Existing ART Sites (Hirschhorn et al. 2007)	- Identifying leaders who will commit and spearhead the programme - Assessing the availability of a plan to provide the programme - Assessing the availability of an approved protocol - Assessing the country's experience in implementing and sustaining other health-related programmes - Ensuring the community involvement to enable local ownership
Rapid Organizational Assessment (United Nations Educational Scientific and Cultural Organization 2012)	- Developing partnerships to implement the programme - Assessing project management, communication and cooperation to implement the programme

Summary

The section above has highlighted the importance of confirming a need and undertaking a readiness assessment when planning a new health service programme. While the process of establishing a new radiotherapy service is complex and multi-faceted, there is no readiness assessment guide designed specifically to provide practical support for LMICs. While the '10-Steps Framework' sets out to address the implementation of new radiotherapy technologies (Brown et al. 2014), its methodological weakness and inadequate coverage of critical success factors limit its applicability to LMICs wishing to establish a de novo radiotherapy service.

Without an accurate readiness self-assessment guide, crucial radiotherapy service establishment process in LMICs could be easily missed, leading to the development of a sub-optimal radiotherapy service that may unintentionally place cancer patients, staff and the public at risk.

The next section presents the development of a draft radiotherapy service development readiness self-assessment guide for use by LMICs.

5.6 Developing a radiotherapy readiness self-assessment guide for use by LMICs

Through the iteration process, the mid-point meta-inference of the ARC Project's data identified four key readiness domains for successful establishment of safe and sustainable radiotherapy services in LMICs, namely: commitment; cooperation; capacity; and catalyst, as defined in Table 5.3. These four domains form the basis of the radiotherapy readiness assessment guide for use by LMICs.

Table 5.3: Definitions for the four key readiness domains

Readiness domains	Definitions
Domain One – “Commitment”	Commitment is defined as an LMIC's willingness to put in place the necessary political, policy, funding and regulatory requirements to enable a radiotherapy service to be established
Domain Two – “Cooperation”	Cooperation is defined as the effective involvement of relevant international, national and local stakeholders in the planning, commissioning and operationalisation of a new radiotherapy service
Domain Three – “Capacity”	Capacity is defined as an LMIC's ability to translate commitment and cooperation to achieve sustainable results through effective and efficient management of the implementation process, a prepared workforce, maintenance, governance and information technology
Domain Four – “Catalyst”	Catalyst is defined as the potential for an LMIC to leverage from a radiotherapy service to develop an integrated cancer care service

Through the ARC Project's mid-point meta-inference, which integrated the data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]) (Donkor et al. 2018; Donkor et al. 2020b), as well as reviewing existing readiness assessment tools, 42 key requirements with 71 criteria were identified and organised into four readiness domains: commitment; cooperation; capacity; and catalyst. The assumption underpinning each of these readiness requirements was that successful radiotherapy service establishment is dependent upon LMICs having the necessary information and knowledge to assess their readiness before implementing a local radiotherapy service. Details of the generated readiness requirements from the ARC Project's mid-point are described below.

5.6.1 Commitment-related requirements

Evident in the ARC Project's mid-point meta-inference was the importance of LMICs' commitment to a vision to improve access to radiotherapy services (Donkor et al. 2018; Donkor et al. 2020b). It revealed that building and sustaining commitment was at the core of any radiotherapy initiative to enable the mobilisation and allocation of the necessary resources. To assess LMICs' commitment to establish safe and sustainable radiotherapy services, the ARC Project's mid-point meta-inference identified 13 critical requirements and 23 criteria, which included:

- **stable and safe political environment:** the mid-point meta-inference revealed that favourable political environment was essential for organising governments' strategies and policies to establish safe and sustainable radiotherapy services. The criteria were:
 - the LMIC has no ongoing civil war or political violence; and
 - the LMIC has government structures and processes defined by rules or laws to support policy-making and service planning
- **quality of basic infrastructure service:** the mid-point meta-inference identified that the availability and accessibility of adequate and quality infrastructure, such as roads, water, electricity and sewerage systems are critical to support the establishment of safe and sustainable radiotherapy services in LMICs. The criteria were:
 - the LMIC has consistent supply of water and electricity over long periods;
 - the LMIC has a plan for backup power to keep the radiotherapy facility functioning; and
 - the LMIC has good road and transport system to the radiotherapy facility site, with parking on-site
- **political window of opportunity:** the mid-point meta-inference found that key public/political figure developing cancer was a major driver to advocate for resources to improve local cancer care services, particularly radiotherapy services. The criterion was:

- an opportunity to advocate for the development of radiotherapy service is presented by a high-profile public figure being diagnosed with cancer who has had to seek therapy outside the LMIC
- **radiotherapy lobbying:** the mid-point meta-inference confirmed that civil society organisations, healthcare professionals, political leaders and community leaders are influence local champions that often serve as advocates for improving access to radiotherapy services. The criterion was:
 - civil society organisations and influential individuals are building political interest in establishing radiotherapy service by collaboratively campaigning, advocating and/or lobbying
- **policy coherence:** the mid-point meta-inference ascertained that a coordinate, non-contradictory and complementary government policies are crucial to ensure long-term financial support to establish and sustain a new radiotherapy service. The criterion was:
 - the Ministry responsible for Health has documents/policies that publicly acknowledge the need to strengthen cancer care, including radiotherapy services(s)
- **cancer control policy:** the mid-point meta-inference identified that the availability of a cancer control policy that is costed and approved by the ministry responsible for health was essential to reduce financial and cancer care fragmentation. The criterion was:
 - the LMIC has a Ministry approved comprehensive cancer control strategy that details the vision, values, directions, budget allocation and timelines to develop or enhance radiotherapy service
- **public statements by political leaders:** the mid-point meta-inference confirmed that supportive public statements from senior political leaders signify endorsement and interest in a plan to establish safe and sustainable services. The criterion was:
 - political leaders have made strong public statements supporting and endorsing the need to effectively and efficiently implement the components of the cancer control priorities as outlined in the cancer control plan
- **access to information:** the mid-point meta-inference found that access to accurate and reliable information (epidemiological data) was a critical factor to improve radiotherapy service planning, development, implementation, monitoring and evaluation. The criterion was:
 - the LMIC has access to reliable and accurate epidemiological data at the institutional or country level which can be used to determine the country's cancer profile as well as determine optimal equipment and facility siting plans

- **suitable funding model:** the mid-point meta-inference identified that radiotherapy financing model was crucial because it was the mechanism by which strategic plans to establishing a radiotherapy service translate into actual reality. It confirmed the importance of long-term financial investment to ensure the maintenance of the radiotherapy service. The criteria were:
 - the LMIC has developed a detailed project plan for the development of the new radiotherapy service that identifies timelines, clear roles and responsibilities for all relevant stakeholders and project milestones;
 - The LMIC and/or an external agency has identified a secure source(s) of ongoing funding for the development of radiotherapy service;
 - the LMIC with assistance from an external agency has prepared budget document to help make case for long-term public, private, philanthropic or partnership financial commitments for the project;
 - the government, private partner and/or philanthropic organisations have obliged to financially support efforts in the LMIC to develop or enhance access to radiotherapy service; and
 - the LMIC has identified and secured funding support for a scale-up implementation approach and ongoing operational sustainability of the service
- **commitment towards universal health coverage:** it was evident that governments' commitment towards universal health coverage was critical to reduce out-of-pocket expenses at the point of radiotherapy service delivery. The criteria were:
 - the LMIC has taken steps toward achieving universal health coverage by establishing a national health insurance program; and
 - the LMIC has taken steps toward achieving universal health coverage by providing government subsidies for selected healthcare services
- **membership status with the IAEA:** the mid-point meta-inference identified that the LMIC becoming a member of the IAEA was essential because radiation risks transcend national borders and IAEA works to promote and enhance the reliable, peaceful and safe use of radiation. The criteria were:
 - the LMIC signed the 26th October 1956 Statute within 90 days after it was opened for signature and became a member of IAEA; and
 - the LMIC has deposited an instrument of acceptance of the Statute to become a member of IAEA
- **legal and regulatory framework:** developing appropriate legal and regulatory framework was confirmed essential because it helps define the scope of radiotherapy

practice, technical requirements and operational procedures to safeguard the delivery of radiotherapy services. The criterion was:

- the LMIC has a legal and regulatory framework to safeguard the use of ionising radiation
- **independent country-level regulator:** it was acknowledged that having an independent country-level regulator was crucial to provide supervisory oversight by inspecting, authorising and enforcing the legislation and regulations to prevent radiation accidents, control hazards and respond to emergencies. The criteria were:
 - the LMIC has created an independent regulator to inspect, authorise actions and enforce the legislation and regulations; and
 - the LMIC has created an independent regulator to ensure compliance with international standards of radiation safety, security and protection

5.6.2 Cooperation-related requirements

The ARC Project's mid-point meta-inference confirmed the importance of appropriately cooperating with relevant stakeholders to strategically plan the establishment of the new radiotherapy service (Donkor et al. 2018; Donkor et al. 2020b). To determine LMICs' cooperation to establish safe and sustainable radiotherapy services, the mid-point meta-inference revealed seven essential requirements and seven related criteria, namely:

- **inclusive planning team:** the mid-point meta-inference revealed that forming a planning team with the right mix of skills, knowledge and experience was critical to ensure effective coordination of the strategic planning activities to establish a new radiotherapy service. Hence, the criterion was:
 - the LMIC has formed a planning team with the right mix of skills, knowledge and experience to coordinate with relevant stakeholders and oversee the planning of the new radiotherapy service, such as carrying out the need assessment and determining the feasibility of the radiotherapy project
- **technical working group:** the mid-point meta-inference identified that creating a functional technical working group was essential to generate the necessary information for defining technical requirements for a safe radiotherapy service. Hence, the criterion was:
 - the LMIC has created a functional technical working group to support the planning team as a coordination and information-sharing group responsible for defining technical requirements and recommendations
- **identify and engage relevant stakeholder:** the mid-point meta-inference confirmed that performing a stakeholder analysis and mapping was crucial to defining, engaging

and gaining a better understanding of stakeholders' expectations. Hence, the criterion was:

- the LMIC has performed a stakeholder analysis to define, engage and gain better understanding of the range of ministries, institutions, organisations, professional bodies and individuals who have interest in and can influence the radiotherapy project
- **technical assistance plan:** it was identified that developing a technical assistance plan was important to avoid duplication of supports from international agencies/organisations. Hence, the criterion was:
 - the LMIC has mapped international technical assistance programmes and invited the designated Agency or organisations to aid where further support is needed while avoiding duplications and conflicting advice
- **stakeholder involvement:** it was found that involving stakeholders through consultations were vital to ensure early buy-in and local ownership of the new radiotherapy service. Hence, the criterion was:
 - the international agency or organisation providing technical assistance has involved relevant in-country stakeholders in broader consultations in defining specific needs, strategic plan and directions to ensure early buy-in of the planning process and local ownership of the new radiotherapy service
- **stakeholder consensus-building:** it was recognised that achieving consensus among stakeholders on priority areas was critical to ensure timely organisation and allocation of significant resources. Hence, the criterion was:
 - the Agency working together with the LMIC have achieved consensus on the priority areas, such as equipment by circulating draft plan and providing opportunity for stakeholders to express their views on the radiotherapy plan
- **trust relationships:** the mid-point meta-inference identified that building a trusting relationship was important to ensure collaborative work between partners. Hence, the criterion was:
 - the LMIC has a good track record based on the previous history of working collaboratively with international development partners

5.6.3 Capacity-related requirements

The ARC Project's mid-point meta-inference confirmed the importance of understanding LMICs' capacity to implement, manage, organise, operationalise and maintain the radiotherapy centre (Donkor et al. 2018; Donkor et al. 2020b). To assess LMICs' capacity to establish safe and

sustainable radiotherapy services, the ARC Project's mid-point meta-inference revealed 17 key requirements and 25 associated criteria, which included:

- **multidisciplinary implementation team:** the mid-point meta-inference revealed that forming a multidisciplinary implementation team to manage the day-to-day implementation tasks and activities was essential to ensure effective implementation of the radiotherapy service. The criterion was:
 - the LMIC has formed a multidisciplinary implementation team to manage the building of the new radiotherapy facility once the radiotherapy plan has been approved at the ministerial level
- **responsible project manager:** it was identified that appointing a responsible project manager with technical and relevant contextual knowledge was critical to help develop timelines and coordinate the radiotherapy service implementation activities. The criterion was:
 - the LMIC has appointed an experienced project manager with technical and relevant contextual knowledge to help develop timelines and coordinate the implementation activities such as construction, equipment procurement, installation and timely training of staff
- **availability of radiotherapy expertise:** access to experts, such as radiation oncologists, medical physicists, engineers and architects with experience in establishing a radiotherapy service is vital to ensure effective design, construction, quality assurance and commission of the local radiotherapy service. The criterion was:
 - the LMIC has relevant local radiotherapy expertise available or when unavailable locally the LMIC has recruited external experts such as clinicians (radiation oncologist and medical physicist), architects, building contractors and engineers to design, construct and commission the new radiotherapy facility in accordance with all regulatory requirements
- **access to suitable land:** the mid-point meta-inference identified that securing suitable land and having it ready for the establishment of the radiotherapy service was important to prevent any environmental and engineering hazards. The criteria were:
 - the LMIC has secured a suitable land, with space for future expansion; and
 - the LMIC has successfully conducted environmental hazard assessment to address environmental issues such as flood and earthquakes
- **construction of the radiotherapy building:** constructing the radiotherapy building with the right materials was recognised as essential to ensure that the facility, including the bunker meets international and national regulations. The criterion was:

- the LMIC has identified and secured the services of experience contractors to complete the building and bunker(s) for housing the radiotherapy equipment in a timely manner
- **equipment purchase, delivery and set-up:** negotiating and purchasing the right equipment helps address the population's radiotherapy service need. Making arrangement for oncology-specific patient information management software, planning systems, simulation machines, dosimetry and immobilisation devices was identified important to ensure appropriate delivery of radiotherapy services. The criteria were:
 - the LMIC has negotiated with a vendor for optimal equipment purchase, timely delivery and installation, with the necessary planning systems, simulation machine and dosimetry devices for monitoring dose equivalent; and
 - the LMIC has made arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment
- **training for initial core staff:** the mid-point meta-inference identified that identifying appropriate candidates for radiotherapy leadership positions and arranging to train core workforce (radiation oncologists, radiation therapists, medical physicists cancer care nurses) were essential to ensure quality and safe delivery of radiotherapy services. The criteria were:
 - the LMIC has selected a dedicated team of health professionals and adequate arrangement made to train them to form the core workforce – radiation oncologists, radiation therapists and medical physicists;
 - the LMIC has requested for assistance from the IAEA to support placement of the candidates in suitable training sites while noting the importance of training on relevant equipment and relevant disease profiles; and
 - the LMIC has a plan to ensure the training commenced immediately the radiotherapy project is approved to reduce delays or engaging services of expatriates
- **other supporting staff:** making arrangement to identify and train other supporting staff, such as, social workers, dieticians and information technologist was vital to ensure cancer patients and their families were appropriately supported. The criterion was:
 - the LMIC has appropriately identified and trained other supporting staff such as cancer care nurses, social workers and case managers or coordinators
- **staff succession plan:** the mid-point meta-inference identified that developing a long-term strategic plan for building in-country radiotherapy specific academic and clinical education was important to ensure the continuous development of radiotherapy

workforce locally while addressing concerns about retirement, change in jobs and brain drain to overseas. Hence, the criteria were:

- the LMIC has a long-term strategic plan for building local training capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff annual leave, retirement, change in jobs and brain drain due to overseas benefits; and
 - the LMIC has knowledge of staffing needs and plan to participate in regional e-learning programmes to address staff knowledge and skill gaps
- **incentive systems:** the mid-point meta-inference identified that developing appropriate financial and non-financial incentive packages for radiotherapy staff was important to help motivate and retain radiotherapy workforce. The criterion was:
 - the LMIC has made arrangement for suitable financial and non-financial incentive systems, including appropriate salaries to motivate and retain staff
- **service contract:** the mid-point meta-inference found that negotiating for service contract was essential to ensure adequate training for local engineers and effective maintenance of the radiotherapy equipment. the criteria were:
 - the LMIC has a contractual service agreement for the purchased equipment to enable timely engineering support to minimise downtime; and
 - the LMIC has arranged to select and train a team of in-house engineers as part of the procurement plan
- **spare parts:** it was identified that generating funds through radiotherapy service charges or government revenue was important to support purchasing of spare and repair parts as well as replacement of obsolete radiotherapy equipment. The criteria were:
 - the LMIC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts; and
 - the LMIC has made arrangement to generate funds to support radiotherapy facilities in their efforts to maintain operation over the long-term period, including purchasing of spare and repair parts and replacement of obsolete equipment
- **governance and management structure:** the mid-point meta-inference found that creating an inclusive radiotherapy service governance and management board was essential to ensure clinical and non-clinical accountability, coalition building, regulation and incentive enforcement. The criterion was:

- the LMIC has created an inclusive governance and management board plan for the new radiotherapy facility to ensure there is participation in higher level radiotherapy decision-making while properly managing the facility by providing leadership, financial governance, strategic direction, setting priorities for continuous improvement and clinical governance such as being accountable to patients and their families
- **treatment guidelines, protocols and standard operating procedures:** developing radiotherapy service guidelines, protocols and standard operating procedures was identified as important because they ensure a high-quality of transparency and accountability. The criterion was:
 - the LMIC has developed or planning to develop radiotherapy guidelines, protocols and standard operating procedures which are required before the first patient treatment
- **other essential health services:** developing a plan to ensure easy access to essential health services such as radiological (e.g. CT scan and ultrasound scan), laboratory, pathology services and nuclear medicine services was identified as significant to ensure diagnosis, treatment and follow-up. The criterion was:
 - the new radiotherapy facility has other essential health services available, such as radiological, laboratory and nuclear medicine on-site or the LMIC has taken steps towards outsourcing such services from nearby health facilities
- **social support services:** providing social services, such as transportation, accommodation and assistance programmes are necessary to help cancer patients and their families access and complete their radiotherapy treatment. The criterion was:
 - the LMIC and/or civil society organisations have programmes in place to provide social support services for patients, such as transport and accommodation assistance scheme
- **generate, compile, analyse and communicate health data:** developing a simple and basic health information system to collect clinical and non-clinical information in a format that meets the dissemination and communication needs is important to aid cancer treatment decision-making. The mid-point meta-inference revealed that the information technologists ought to be trained to implement appropriate safeguards to protect patient data confidentiality. The criteria were:
 - the LMIC has appropriate health information system in place to collect clinical and non-clinical information in formats that meet the dissemination and communication needs of care providers, managers, patients and families to aid decision-making; and

- the LMIC has adequately trained users in all levels to use the information technology

5.6.4 Catalyst-related requirements

The ARC Project's mid-point meta-inference confirmed the availability of a radiotherapy service as a catalyst to further strengthen the development of integrated cancer care in LMICs (Donkor et al. 2018; Donkor et al. 2020b). It revealed that through the availability of a new radiotherapy service, LMICs can be supported to think about harmonisation and orientation of cancer care services around patients, as well as investment in cancer research. The mid-point meta-inference identified five key catalyst-related requirements and 16 criteria, namely:

- **encourage cancer control reform:** the mid-point meta-inference identified that it is critical to recognise a radiotherapy service as a window of opportunity to reform cancer care by motivating political and health leaders to think about a comprehensive cancer service. The criteria were:
 - the LMIC has plans to use the new radiotherapy service to persuade relevant stakeholders to think differently about cancer care;
 - the LMIC has plans to use the new radiotherapy service to promote comprehensive service and optimise cancer prevention, diagnosis, treatment and palliative care outcomes; and
 - the LMIC has plans to use the new radiotherapy service to and sensitize policy-makers and health authorities to the growing burden of cancer and the importance of integrated cancer control strategies for managing it
- **promote coordinate care:** it was identified that developing appropriate patient referral pathways and registries is critical to improve transition across specialists. The criteria were:
 - the LMIC has plans to use the new radiotherapy service to upgrade information systems to improve coordination of care across providers, facilities and settings;
 - the LMIC has plans to use the new radiotherapy service to develop patient referral pathways and registries to increase transition across specialists; and
 - the LMIC has plans to use the new radiotherapy service to develop nurse coordinators to support patients as they navigate the cancer care settings
- **promote a multidisciplinary approach to care:** developing a plan to implement a multidisciplinary team to manage the planning and treatment of cancer patients was essential for harnessing the collective knowledge, information and skills of multiple cancer specialists. The criteria were:

- the LMIC has plans to use the new radiotherapy service to advocate for the promotion and implementation of multidisciplinary team management of cancer patients; and
- the LMIC has plans to use the new radiotherapy service to develop and implement national cancer management guideline in collaboration with other specialities
- **strengthen patient and family-centred care:** the mid-point meta-inference identified that through the new radiotherapy service, a plan can be developed to provide cancer patients and their families access to basic information about cancer management and self-management support outside the healthcare setting. The criteria were:
 - the LMIC has plans to use the new radiotherapy service to provide patients and families access to basic information about cancer management and self-management support outside the healthcare setting through telephone or internet;
 - the LMIC has plans to use the new radiotherapy service to develop educational and skill-building programmes for patients and families on the management of cancer;
 - the LMIC has plans to use the radiotherapy service to anticipate and better meet the needs of cancer patients (example, transport, accommodation and food is an incentive for low-income patients to adhere to treatment);
 - the LMIC has plans to use the new radiotherapy service to develop written materials to support self-management strategies; and
 - the LMIC has plans to use the new radiotherapy service to build stronger connection with the community to educate the community at large about the prevention of cancer
- **encourage better outcomes through research:** the mid-point meta-inference identified that building international and/or regional research collaborations was essential to ensure the exchange of information and sharing of expertise, policies and strategies to improve cancer care. The criteria were:
 - the LMIC has plans to use the new radiotherapy service to emphasise the importance of evidence-based cancer care;
 - the LMIC has plans to use the new radiotherapy service to support the conduct of local research to produce and demonstrate the cost-effectiveness of innovative care and strategies; and
 - the LMIC has plans to use the new radiotherapy service to establish international and regional collaborations where radiotherapy centres can

exchange information, share expertise, policies and strategies to improve services

These lists of requirements and criteria were presented to the participants in Study Two [Part B], which forms the basis for the development of a readiness self-assessment for LMICs establishing safe and sustainable radiotherapy services. The development of a readiness self-assessment guide may help to ensure that LMICs are able to pro-actively identify all of the potential barriers and facilitators they may encounter at the outset, and to map the sequencing of the various different requirements so they can realistically appraise their capacity to deliver quality, safe and effective local radiotherapy services, on time and budget.

Summary

This Chapter has reported on the mid-point meta-inference, which integrated the data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]). The Chapter summarised approaches to need and readiness assessment, and reported definitions and requirements that make up the four domains of a radiotherapy service development guide for LMICs who are contemplating on establishing a local sustainable radiotherapy service(s). The next Chapter reports on the findings of the participant validation process (Study Two [Part B]) of the proposed radiotherapy service development guide for LMICs establishing safe and sustainable radiotherapy services.

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Chapter Six: Findings–Participant Validation Process (Study Two [Part B])

6.1 Overview

As indicated in Chapter One, achieving universal radiotherapy access is a global health concern. Health and cancer organisations and agencies, such as the IAEA, WHO and UICC are working tirelessly in LMICs to ensure that radiotherapy services are more accessible and available to everyone who needs them (Abdel-Wahab, Lahoupe, et al. 2017; Abdel-Wahab, Zubizarreta, et al. 2017; Adams et al. 2017). Improving access to radiotherapy services has largely developed in response to the increasing cancer burden in LMICs, accompanied by awareness and advocacy strategies. Globally, LMICs governments are being encouraged to commit resources to establish safe and sustainable radiotherapy services to address the evolving cancer treatment needs of their populations (Abdel-Wahab, Fidarova & Polo 2017).

Radiotherapy is clinically indicated for more than half of all cancer cases, as either a treatment to cure, palliate and/or improve the patient's quality of life. Improving cancer outcomes of working-age people increases labour force participation (Atun et al. 2015). When successfully established, a local radiotherapy service provides both health and economic benefits for the individual, their family and the broader society (Atun et al. 2015; Rodin et al. 2019). Similar to other health projects, a poorly implemented radiotherapy service has negative impacts on cancer patients' outcomes, wastes scarce financial resources, damages industry integrity, and contributes to a population's mistrust (Johnson 2009; Rosenblatt 2014). The success of establishing a new radiotherapy service is dependent upon being completed according to the agreed plan on time, within budget and meeting all the various quality and safety requirements. Many new radiotherapy services fail because of poor stakeholder engagement, fatal construction flaw(s), procuring unsuitable equipment and not integrating maintenance into the longer-term project plan (Donkor et al. 2018). In addition to these barriers, establishing safe and sustainable radiotherapy services in LMICs have been hindered by challenges such as the lack of political support, absence of radiotherapy expertise, ineffective project management, lack of radiation safety infrastructure and weak contract management (Brown et al. 2014; Grover et al. 2014).

The findings from the semi-structured interviews with global radiotherapy experts reported in Chapter Four identified that assessing LMICs' readiness to establish safe and sustainable radiotherapy services has become an essential element of the planning process. Understanding LMICs' readiness to embark on developing a new radiotherapy service is critical to governments, planners, coordinators and regulators so that they can better support investment decisions and better guide the entire establishment process (Donkor et al. 2020). Readiness refers to the state of being prepared to undertake the implementation of any development project (World Economic Forum 2017). A readiness assessment can be conducted systematically using qualitative or quantitative indicators, or a mixture of both (Holt et al. 2007).

While quantitative readiness indicators can provide numerical snapshots of the preparedness, qualitative readiness indicators offer insightful information necessary for understanding and defining the requirements for evidence-based monitoring and evaluation (Holt et al. 2007; Zall Kusek & Rist 2004). Both qualitative and quantitative readiness indicators are widely used as planning, self-assessment or managerial tools to identify progress, opportunities and barriers aimed at informed decision-making, accountability, learning, designing and selecting appropriate strategies to maximise achievement of results (Gholamhosseini & Ayatollahi 2017; Rodriguez-Garcia & White 2005).

Establishing a safe and sustainable radiotherapy service is a complex multiple stage process (Abdel-Wahab, Fidarova & Polo 2017). Despite this complexity, there is a lack of readiness self-assessment guides to provide practical support for LMICs to determine their capacity at the outset to progress the establishment of safe and sustainable radiotherapy services. As outlined in Chapter Five, a list of potential radiotherapy service development readiness guidance requirements were generated through the mid-point meta-inference, which was informed by integrating the systematic review (Study One) and semi-structured interview (Study Two [Part A]) data. This meta-inference identified a set of 42 potential requirements and 71 potential criteria that ought to be considered for inclusion in a radiotherapy service development readiness self-assessment guide for LMICs, contemplating establishing new local radiotherapy services.

This draft guidance list was distributed to the global radiotherapy experts who participated in the semi-structured interviews (Study Two [Part A]) to confirm or refute its relevance to the sector and to assist with its refinement. This Chapter reports on this participant validation process (Study Two [Part B]).

The participant validation process study was published in 2020 in *Physica Medica*. Chapter Six contains an edited version of the publication, which is provided in Appendix L.

6.2 Publication reference

Donkor, A., Luckett, T., Aranda, S., Vanderpuye, V. & Phillips, J.L. 2020, 'Developing a readiness self-assessment tool for low- and middle-income countries establishing new radiotherapy services: a participant validation study', *Physica Medica*, vol. 71, pp. 88-99.

6.3 Objective

To seek feedback from the global radiotherapy experts' who contributed to Study Two [Part A] about the utility of the potential radiotherapy service development readiness assessment requirements for LMICs identified during the ARC Project's mid-point meta-inference.

6.4 Methods

Chapter Three has provided a complete description of the methods for data collection and analysis for the participant validation process (Study Two [Part B]).

6.5 Findings from the participant validation process

A total of 17 invitations were distributed via email, with seven global radiotherapy experts participating in the validation process. Ten experts did not participate for the following reasons: no response after two email follow-ups (n=7); or other pressing work priorities (n=3). The final response rate was 41.2% (n=7). The majority of the participants (n=4) who took part in the validation process were females. One participant completed the validation process via a telephone conversation, while the remaining completed and submitted it through email correspondence. Three participants were working permanently in Australia. The other participants were working in Jordan (n=1), India (n=1), Ethiopia (n=1) and Zambia (n=1). Five of the participants were radiation/clinical oncologists and two were radiation therapists.

Table 6.1 shows the original 42 requirements and 71 criteria, with participants' feedback in regard to whether it was: relevant (accept); not relevant (remove) or needed to be refined (modify).

Table 6.1: Original requirements and criteria, with participants' feedback

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
Commitment	safe and stable political environment	The LMIC has no ongoing civil war or political violence.	A	M	A	A	A	R	R	<i>"Delay in our radiotherapy projects are directly or indirectly related to unstable political situation. I would be happy if this is not excluded" – (P10, CO, Local)</i>
		The LMIC has government structures and processes defined by rules or laws to support policy-making and service planning.	A	M	A	A	A	A	R	
	Quality of basic infrastructure service	The LMIC has consistent supply of water and electricity over long periods.	A	M	A	A	A	A	A	<i>"Include sewerage too. I have been to some radiation therapy centres in LMICs where there are no toilets" – (P6, RT, International)</i>
		The LMIC has a plan for backup power to keep the radiotherapy facility functioning.	A	A	A	A	A	A	A	
		The LMIC has good road and transport system to the radiotherapy facility site, with parking on-site.	M	M	A	A	A	M	M	<i>"I feel that roads and transport are important, parking could be nearby and not necessarily onsite" – (P1, RO, International)</i>
	Political window of opportunity	An opportunity to advocate for the development of radiotherapy service is presented by a high-profile public figure being diagnosed with cancer who has had to seek therapy outside the LMIC.	R	A	A	A	M	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
	Radiotherapy lobbying	Civil society organisations and influential individuals are building political interest in establishing radiotherapy service by collaboratively campaigning, advocating and/or lobbying.	A	A	A	A	A	A	A	
	Policy coherence	The Ministry responsible for Health has documents/policies that publicly acknowledge the need to strengthen cancer care, including radiotherapy services(s).	A	A	A	A	A	A	A	
	Cancer control policy	The LMIC has a Ministry approved comprehensive cancer control strategy that details the vision, values, directions, budget allocation and timelines to develop or enhance radiotherapy service.	A	A	A	A	A	A	A	
	Public statements by political leaders	Political leaders have made strong public statements supporting and endorsing the need to effectively and efficiently implement the components of the cancer control priorities as outlined in the cancer control plan.	M	A	A	A	A	A	M	<i>"It may not be possible to implement all elements of a national cancer control plan in one go...[but]...radiotherapy is effective if introduced within a comprehensive cancer control plan" – (P1, RO, International)</i>
	Identified require information	The LMIC has access to reliable and accurate epidemiological data at the institutional or country level which can be used to determine the country's cancer profile as well as determine optimal equipment and facility siting plans.	A	M	A	A	A	M	A	<i>"Maybe say they must commit to creating a cancer registry" –(P6, RT, International)</i>

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
	Suitable funding model	The LMIC has developed a detailed project plan for the development of the new radiotherapy service that identifies timelines, clear roles and responsibilities for all relevant stakeholders and project milestones.	A	A	A	A	A	A	A	
		The LMIC and/or an external agency has identified a secure source(s) of ongoing funding for the development of radiotherapy service.	A	A	A	A	M	A	A	
		The LMIC with assistance from an external agency has prepared budget document to help make case for long-term public, private, philanthropic or partnership financial commitments for the project.	A	A	A	A	M	A	A	<i>“Ensure that accessory replacement and maintenance cost are included” – (P10, CO, Local)</i>
		The government, private partner and/or philanthropic organisations have obliged to financially support efforts in the LMIC to develop or enhance access to radiotherapy service.	A	A	A	A	M	A	A	
		The LMIC has identified and secured funding support for a scale-up implementation approach and ongoing operational sustainability of the service.	A	A	A	A	M	A	A	
	Committed to Universal Health Coverage	The LMIC has taken steps toward achieving universal health coverage by establishing a national health insurance program.	M	A	A	A	A	M	A	<i>“These two criteria on UHC could be combined” – (P1, RO, International)</i>

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		The LMIC has taken steps toward achieving universal health coverage by providing government subsidies for selected healthcare services.	M	A	A	A	A	M	A	
	Membership status with the International Atomic Energy Agency (IAEA)	The LMIC signed the 26 th October 1956 Statute within 90 days after it was opened for signature and became a member of IAEA.	M	A	A	A	A	A	A	
		The LMIC has deposited an instrument of acceptance of the Statute to become a member of IAEA.	M	A	A	A	A	A	A	
	Legal and regulatory framework	The LMIC has a legal and regulatory framework to safeguard the use of ionising radiation.	A	A	A	A	A	A	A	
	Independent country-level regulator	The LMIC has created an independent regulator to inspect, authorise actions and enforce the legislation and regulations.	M	A	A	A	A	A	A	
		The LMIC has created an independent regulator to ensure compliance with international standards of radiation safety, security and protection.	M	A	A	A	A	A	A	
Cooperation	Inclusive planning team	The LMIC has formed a planning team with the right mix of skills, knowledge and experience to coordinate with relevant stakeholders and oversee the planning of the new radiotherapy service, such as carrying out the need	A	M	A	A	M	A	A	"Maybe use the term 'strategic planning' so there is no confusion between it and radiation therapy planning" – (P6, RT, International)

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		assessment and determining the feasibility of the radiotherapy project.								
	Technical working group	The LMIC has created a functional technical working group to support the planning team as a coordination and information-sharing group responsible for defining technical requirements and recommendations.	M	A	A	A	A	A	A	<i>"I'm not sure how this is completely separate from the inclusive planning team" – (P1, RO, International)</i>
	Identify and engage relevant stakeholders	The LMIC has performed a stakeholder analysis to define, engage and gain better understanding of the range of ministries, institutions, organisations, professional bodies and individuals who have interest in and can influence the radiotherapy project.	A	A	A	A	R	A	A	
	Technical assistance plan	The LMIC has mapped international technical assistance programmes and invited the designated Agency or organisations to aid where further support is needed while avoiding duplications and conflicting advice.	A	A	A	A	A	A	A	
	Stakeholder involvement	The international agency or organisation providing technical assistance has involved relevant in-country stakeholders in broader consultations in defining specific needs, strategic plan and directions to ensure early buy-in of the planning process and local ownership of the new radiotherapy service.	A	A	A	A	A	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
	Stakeholder consensus-building	The Agency working together with the LMIC have achieved consensus on the priority areas, such as equipment by circulating draft plan and providing opportunity for stakeholders to express their views on the radiotherapy plan.	M	A	A	A	A	A	M	<i>"Consider combining this and the other stakeholder requirements" – (P17, RT, International)</i>
	Trust relationships	The LMIC has a good track record based on the previous history of working collaboratively with international development partners.	R	R	A	R	R	R	R	
Capacity	Multidisciplinary implementation team	The LMIC has formed a multidisciplinary implementation team to manage the building of the new radiotherapy facility once the radiotherapy plan has been approved at the ministerial level.	A	M	A	A	A	A	A	
	Responsible project manager	The LMIC has appointed an experienced project manager with technical and relevant contextual knowledge to help develop timelines and coordinate the implementation activities such as construction, equipment procurement, installation and timely training of staff.	A	A	A	A	A	A	A	
	Availability of radiotherapy expertise	The LMIC has relevant local radiotherapy expertise available or when unavailable locally the LMIC has recruited external experts such as clinicians (radiation oncologist and medical physicist), architects, building contractors and engineers to design, construct and	A	A	A	A	A	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		commission the new radiotherapy facility in accordance with all regulatory requirements.								
	Access to a suitable land	The LMIC has secured a suitable land, with space for future expansion.	M	M	A	A	A	A	M	
		The LMIC has successfully conducted environmental hazard assessment to address environmental issues such as flood and earthquakes.	A	M	A	A	A	A	A	<i>“Add engineering hazard assessment to mitigate natural disaster and construction engineering risks to the statement” – (P6, RT, International)</i>
	Construction of the building	The LMIC has identified and secured the services of experience contractors to complete the building and bunker(s) for housing the radiotherapy equipment in a timely manner.	A	A	A	A	A	A	M	
	Equipment purchase, delivery and set-up	The LMIC has negotiated with a vendor for optimal equipment purchase, timely delivery and installation, with the necessary planning systems, simulation machine and dosimetry devices for monitoring dose equivalent.	A	M	A	A	A	A	A	<i>“Add oncology specific patient information management software and other accessory equipment to the statement” – (P6, RT, International)</i>
		The LMIC has made arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment.	A	A	A	A	A	A	A	
	Training for initial core staff	The LMIC has selected a dedicated team of health professionals and adequate arrangement made to train them to form the core workforce – radiation oncologists,	M	M	A	A	A	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		radiation therapists, medical physicists and cancer care nurses.								
		The LMIC has requested for assistance from the IAEA to support placement of the candidates in suitable training sites while noting the importance of training on relevant equipment and relevant disease profiles.	M	M	A	A	A	A	A	
		The LMIC has a plan to ensure the training commenced immediately the radiotherapy project is approved to reduce delays or engaging services of expatriates.	R	A	A	A	A	A	A	
Other supporting staff		The LMIC has appropriately identified and trained other supporting staff such as social workers and case managers or coordinators.	M	A	A	A	M	A	A	<i>"Add dieticians and occupational therapy services to the statement" – (P11, RO, Local)</i>
Staff succession plan		The LMIC has a long-term strategic plan for building local training capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff annual leave, retirement, change in jobs and brain drain due to overseas benefits.	A	M	A	A	A	A	A	
		The LMIC has knowledge of staffing needs and plan to participate in regional e-learning programmes to address staff knowledge and skill gaps.	A	M	A	A	A	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
	Incentive systems	The LMIC has made arrangement for suitable financial and non-financial incentive systems, including appropriate salaries to motivate and retain staff.	R	M	A	A	M	A	R	<i>"In my experience lack of incentive is demotivating staff in reality" – (P10, CO, Local)</i>
	Service contract	The LMIC has a contractual service agreement for the purchased equipment to enable timely engineering support to minimise downtime.	A	A	A	A	A	A	M	<i>"In the longer term it might mean [training] local engineers or if critical mass is an issue, then a sub-regional network, such as West African engineers' group who service multiple countries" – (P17, RT, International)</i>
		The LMIC has arranged to select and train a team of in-house engineers as part of the procurement plan.	A	A	A	A	A	A	A	
	Spare parts	The LMIC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts.	A	A	A	A	M	A	M	
		The LMIC has made arrangement to generate funds to support radiotherapy facilities in their efforts to maintain operation over the long-term period, including purchasing of spare and repair parts and replacement of obsolete equipment.	M	M	A	A	A	A	A	<i>"This can be built into fee scheduling for patient services in either a public or private setting" – (P6, RT, International)</i>
	Governance and management structure	The LMIC has created an inclusive governance and management board plan for the new radiotherapy facility to ensure there is	M	A	A	A	A	A	M	<i>"I would suggest a point here about radiotherapy articulating with other cancer services, such as surgery,</i>

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		participation in higher level radiotherapy decision-making while properly managing the facility by providing leadership, financial governance, strategic direction, setting priorities for continuous improvement and clinical governance such as being accountable to patients and their families.								<i>medical oncology, diagnostics and palliative care” – (P17, RT, International)</i>
	Treatment guidelines, protocols and standard operating procedures	The LMIC has developed or planning to develop radiotherapy guidelines, protocols and standard operating procedures which are required before the first patient treatment.	R	M	A	A	A	A	A	<i>“These may not be all completed before the 1st treatment but important to develop maybe 1st 12 months. – (P1, RO, International)</i>
	Other essential health services	The new radiotherapy facility has other essential health services available, such as radiological, laboratory and nuclear medicine on-site or the LMIC has taken steps towards outsourcing such services from nearby health facilities.	A	A	A	A	A	A	A	
	Social support services	The LMIC and/or civil society organisations have programmes in place to provide social support services for patients, such as transport and accommodation assistance scheme.	A	M	A	A	A	A	A	
	Generate, compile, analyse and communicate health data	The LMIC has appropriate health information system in place to collect clinical and non-clinical information in formats that meet the dissemination and communication needs of care providers, managers, patients and families to aid decision-making.	R	M	A	A	A	A	A	<i>“Ideal to have but perhaps not essential for first starting” – (P1, RO, International)</i>

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		The LMIC has adequately trained users in all levels to use the information technology.	R	A	A	A	A	A	A	
Catalyst	Encourage cancer control reform	The LMIC has plans to use the new radiotherapy service to persuade relevant stakeholders to think differently about cancer care.	R	M	A	A	A	A	A	<i>"This may be too broad" – (P6, RT, International)</i>
		The LMIC has plans to use the new radiotherapy service to promote comprehensive service and optimise cancer prevention, diagnosis, treatment and palliative care outcomes.	A	M	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to and sensitize policy-makers and health authorities to the growing burden of cancer and the importance of integrated cancer control strategies for managing it.	A	A	A	A	A	A	A	
	Promote coordinated care	The LMIC has plans to use the new radiotherapy service to upgrade information systems to improve coordination of care across providers, facilities and settings.	R	A	A	A	A	A	A	<i>"Ideal but not essential. Hard to cover all these aspects when resources are limited" – (P1, RO, International)</i>
		The LMIC has plans to use the new radiotherapy service to develop patient referral pathways and registries to increase transition across specialists.	A	A	A	A	M	A	A	
		The LMIC has plans to use the new radiotherapy service to develop nurse	R	A	A	A	M	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		coordinators to support patents as they navigate the cancer care settings.								
	Promote a multidisciplinary approach to care	The LMIC has plans to use the new radiotherapy service to advocate for the promotion and implementation of multidisciplinary team management of cancer patients	A	A	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to develop and implement national cancer management guideline in collaboration with other specialities.	A	A	A	A	A	A	A	
	Strengthen patient- and family-centred care	The LMIC has plans to use the new radiotherapy service to provide patients and families access to basic information about cancer management and self-management support outside the healthcare setting through telephone or internet.	R	A	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to develop educational and skill-building programmes for patients and families on the management of cancer.	R	A	A	A	A	A	A	
		The LMIC has plans to use the radiotherapy service to anticipate and better meet the needs of cancer patients (example, transport, accommodation and food is an incentive for low-income patients to adhere to treatment).	A	M	A	A	A	A	A	

Domains	Requirements	Criteria	P1	P6	P7	P10	P11	P16	P17	Comment
		The LMIC has plans to use the new radiotherapy service to develop written materials to support self-management strategies.	R	M	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to build stronger connection with the community to educate the community at large about the prevention of cancer.	R	R	A	A	A	A	A	
Encourage better outcomes through research		The LMIC has plans to use the new radiotherapy service to emphasise the importance of evidence-based cancer care.	R	M	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to support the conduct of local research to produce and demonstrate the cost-effectiveness of innovative care and strategies	A	A	A	A	A	A	A	
		The LMIC has plans to use the new radiotherapy service to establish international and regional collaborations where radiotherapy centres can exchange information, share expertise, policies and strategies to improve services.	A	A	A	A	A	A	A	

Legend: P – Participant; R – Remove; M – Modify; and A – Accept

6.6 Requirements identification and confirmation

The following section reports the requirements that participants confirmed as relevant for inclusion in a potential radiotherapy service development readiness self-assessment guide for use by LMICs.

6.6.1 Commitment-related requirements and criteria

Of the 13 identified draft commitment requirements, participants confirmed 12 as relevant for inclusion. Most participants indicated that two requirements “political window of opportunity” and “radiotherapy lobbying” convey advocacy messages to gain political commitment. Based on this feedback, these two requirements were merged into a single requirement, framed as “opportunities for advocacy”. Even though two participants suggested that the first criterion that defines “stable and safe political environment” as a requirement should be removed, it was included because it was considered that a stable and safe political environment was needed to attract long-term investment and gain the necessary technical support from international agencies and organisations for the establishment of a safe and sustainable radiotherapy service. Safe political environment is important to enforce laws and prevent the use of radioactive material for hostile purposes.

Participants’ favoured the requirement “access to basic infrastructure”, confirming the important role of water, electricity and roads infrastructure for establishing a new radiotherapy service. The first and third criteria for the requirement “access to basic infrastructure” were reworded to include the phrases “has a plan to construct sewerage systems at the radiotherapy facility” and “with adequate onsite or nearby parking for staff, patients and their families, and enable goods to be delivered to the facility” respectively. Criteria for the four requirements “identified require information”, “cancer control policy”, “policy coherence” and “public statements by political leaders” were confirmed as important for inclusion because they concern avenues to engage policy to improve radiotherapy services. The requirement “identified require information” was reworded as “access to information” for clarity. Participants unanimously confirmed the need to identify an appropriate funding model, with a long-term budgetary commitment to establish and maintain the radiotherapy service.

Based on participants comments, the word “maintenance” was introduced into the third criterion for the requirement “suitable funding model”, which was changed to read “the LMIC and/or an external agency has identified a secure source(s) of funding for the development and maintenance/operational sustainability of the radiotherapy service”. The requirement “commitment to universal health coverage” was considered critical in ensuring that patients and their families are protected from the financial burden associated with accessing a radiotherapy service. Three of the top-endorsed requirements - “membership status with IAEA”, “legal and regulatory framework” and “independent LMIC-level regulator” - reflect the value attached to

radiation protection and safety. There was general feedback to merge criteria within the radiation safety requirements.

6.6.2 Cooperation-related requirements and criteria

Criteria for six of the seven original cooperation requirements were confirmed as relevant for inclusion. The requirement “trust relationship” was dropped as it was considered less relevant by six out of seven participants. Based on participants’ comments, two requirements “identify and engage relevant stakeholders” and “stakeholder consensus-building” were merged and incorporated into the requirement “stakeholder involvement”. Efforts to make information available and keep stakeholders informed about the radiotherapy development activities were critical to ensuring national and international stakeholders participate in the planning process. “Technical assistance plan” as a requirement was considered necessary to achieve coherent collaboration and teamwork. Participants suggested merging the two requirements “inclusive planning team” and “technical working group” into a single requirement “strategic planning team” for coordination and overseeing the strategic planning of the new radiotherapy service.

6.6.3 Capacity-related requirements and criteria

Participants confirmed criteria for 16 of the 17 original requirements related to capacity as relevant for inclusion. In relation to effective management capabilities to implement a radiotherapy service, all the participants confirmed the importance of creating a multidisciplinary implementation team, appointing a responsible project manager, securing suitable land and allocating resources for building construction process, equipment purchase, delivery and installation. Four requirements “training for initial core staff”, “training other supporting staff”, “staff succession plan” and “incentive systems” were focused on addressing local radiotherapy workforce development. Two of the participants suggested that the requirement “incentive systems” should be removed. However, it was included because other participants acknowledged that the lack of incentive was a major contributing factor to the brain drain in most LMICs.

Minor typographical errors were corrected to improve readability. For example, “access to a suitable land” was reworded “access to suitable land”. Participants confirmed criteria for two requirements “governance and management structure” and “treatment guidelines, protocols and standard operating procedures” as critical to ensuring a high-quality of transparency and accountability. The implementation of simple and basic information systems was required to generate, compile, analyse and communicate health data. The second criterion for the requirement “generate, compile, analyse and communicate health data” was reworded to “the LMIC has well-trained information technologists to implement appropriate safeguards to protect patient data confidentiality”. Criteria for two requirements “service contract” and “spare parts” were endorsed, reflecting the importance of regular maintenance and repair.

6.6.4 Catalyst-related requirements and criteria

There was relatively high endorsement of all five original requirements related to catalyst. Participants confirmed that radiotherapy services can facilitate the harmonisation and integration of cancer service delivery by addressing three key requirements: “encouraging cancer control reform”; “promoting coordinated care”; and “promoting a multidisciplinary approach to care”. Also, participants confirmed the importance of orienting cancer care around patients and their families to address their broader needs. Participants' comments and keywords to improve the catalyst-related criteria were indicative of the need to clarify, insert missing information and elaborate criteria for the following requirements: “encourage cancer control reform”; “strengthen patient- and family-centred care”; and “encourage better outcomes through research”. For instance, to accommodate the views of participants, the missing information “the need to implement cancer registry through partnerships” was inserted into the first criterion for the requirement “encourage better outcomes through research”. Similarly, the second criterion for the requirement “promote a multidisciplinary approach to care” was slightly reworded to clarify that establishing a radiotherapy service can be used “as a window of opportunity” for the development and implementation of oncology clinical practice guidelines.

6.6.5 Evaluating the comprehensiveness of requirements and criteria

Comprehensiveness was assessed based on the need for additional requirements and/or criteria required to make each readiness domains complete. Importantly, none of the participants suggested any additional requirement, which confers confidence about the comprehensiveness of the guidance list. However, nine new criteria were developed by integrating the wording that participants had used when describing the original requirements.

Table 6.2 presents the refined readiness requirements and criteria that emerged from participants' comments. The additional criteria that emerged from participants' comments are highlighted in bold in the Table to indicate that the requirement or criterion has been modified in accordance with participants' comments.

Table 6.2: Refined requirements and criteria that ought to be used to assess LMICs' readiness to establish safe and sustainable radiotherapy services

Domain	Requirements	Criteria
Commitment	Safe, stable and supportive political environment	1. The LMIC has no ongoing civil war or political violence to divert attention and resource away from cancer treatment and care.
		2. The LMIC has government structures and processes defined by rules or laws to provide important support for policy-making and development of public infrastructure.
		3. AC: The LMIC has no international sanction imposed on it, so as not to impede the work of international radiation oncology volunteers and experts.
	Quality of basic infrastructure service	4. The LMIC has made arrangement to ensure supply of water, electricity to the radiotherapy service centre and has a plan to construct sewerage systems at the radiotherapy service centre.
		5. The LMIC has a plan for backup power to keep the radiotherapy service functioning.
		6. The LMIC has road and transport system to the radiotherapy service site, with adequate onsite or nearby for staff, patients and their families, as well as enable goods to be delivered to the radiotherapy service centre.
	Opportunities for advocacy	7. Champions have identified opportunities to advocate for the development of a radiotherapy service , such as a high-profile and influential public figure being diagnosed with cancer.
		8. Civil society organisations and influential individuals are building political interest in establishing radiotherapy service by collaboratively campaigning, advocating and/or lobbying.
		9. AC: The high-profile figure is a committed advocate and has the power to influence the decision to improve access to cancer treatment and care, including radiotherapy.
	Policy coherence	10. The Ministry responsible for Health has documents/policies that publicly acknowledge the need to strengthen cancer care, including radiotherapy services(s).
	Cancer control policy	11. The LMIC has a Ministry approved comprehensive cancer control strategy that details the vision, values, directions, budget allocation and timelines to develop or enhance radiotherapy service.
		12. AC: The LMIC understands that radiotherapy is beneficial and effective when introduced within a national cancer control plan.

Domain	Requirements	Criteria
	Public statements by political leaders	13. Political leaders have made strong public statements supporting and endorsing the need to align priorities and effectively implement the components as outlined in the cancer control plan in a prioritised manner.
	Access to information	14. Preferably, the LMIC has access to reliable and accurate epidemiological data at the institutional or LMIC-level which can be used to determine the LMIC's cancer burden, thus enabling determination of optimal equipment, service siting and estimation of annual radiotherapy utilisation rate (demand for service). 15. AC: The LMIC has access to global cancer data (GLOBOCAN) and has plans to establish a cancer registry through the support of International Agency for Research on Cancer (IARC) Global Initiative for Cancer Registry Development (GICR).
	Suitable funding model	16. The LMIC has developed a detailed project plan for the development of the new radiotherapy service that identifies timelines, clear roles and responsibilities for all relevant stakeholders and project milestones. 17. The LMIC and/or an external agency has identified a secure source(s) of funding for the development and maintenance/operational sustainability of the radiotherapy service. 18. The LMIC with assistance from an external agency has prepared a budget document to help make a case for long-term public, private, philanthropic or partnership financial commitments to develop or enhance access to radiotherapy service. 19. AC: The LMIC has completed a health economic analysis to help make a business case.
	Commitment to Universal Health Coverage	20. The LMIC has taken steps toward achieving universal health coverage by establishing a national health insurance program or government subsidies for cancer treatment and care to help protect patients and their families from financial hardships associated with accessing radiotherapy
	Membership status with the International Atomic Energy Agency (IAEA)	21. The LMIC signed the 26 th October 1956 Statute within 90 days after it was opened for signature or has deposited an instrument of acceptance of the Statute to become a member of IAEA.
	Legal and regulatory framework	22. The LMIC has a legal and regulatory framework to safeguard the use of ionising radiation.
	Independent LMIC-level regulator	23. The LMIC has created an independent regulator to: i) inspect, authorise actions and enforce the legislation and regulations; and ii) ensure compliance with international standards of radiation safety, security and protection.

Domain	Requirements	Criteria
Cooperation	Strategic planning team	24. The LMIC has formed a strategic planning team with the right mix of skills, knowledge and experience to coordinate with relevant stakeholders and oversee in detail specific strategic planning of the new radiotherapy service, such as carrying out the need assessment and determining the feasibility of the radiotherapy project.
		25. Within the strategic planning team, the LMIC has created a functional technical working group to support as an information-sharing group responsible for defining technical requirements and recommendations.
		26. AC: Members of the radiotherapy project team have enabled a smooth articulation between radiotherapy and any existing cancer services in the LMIC.
	Stakeholder involvement	27. The LMIC has performed a stakeholder analysis to define, engage and gain a better understanding of the range of ministries, institutions, organisations, professional bodies and individuals who have interest in and can influence the radiotherapy project.
		28. The international agency or organisation providing technical assistance has involved relevant in-LMIC stakeholders in broader consultations in defining specific needs, strategic plan and directions to ensure early buy-in of the planning process and local ownership of the new radiotherapy service.
		29. The Agency working together with the LMIC have achieved consensus on the priority areas, such as equipment by undertaking due diligence, circulating draft plan and providing an opportunity for stakeholders to express their views on the radiotherapy plan.
Capacity	Technical assistance plan	30. The LMIC has mapped international technical assistance programmes and invited the designated Agency or organisations to aid where further support is needed while avoiding duplications and conflicting advice.
		31. AC: The extent and mechanisms for the technical assistance have been clearly defined by the LMIC and the international agency or organisation.
	Multidisciplinary implementation team	32. The LMIC has formed a multidisciplinary implementation team that is responsible for the day-to-day management of the building of the new radiotherapy service once the radiotherapy plan has been approved at the ministerial level.
	Responsible project manager	33. The LMIC has appointed an experienced project manager with technical and relevant contextual knowledge to help develop timelines and coordinate the implementation activities such as construction, equipment procurement, installation and timely training of staff.

Domain	Requirements	Criteria
	Availability of radiotherapy expertise	34. The LMIC has relevant local radiotherapy expertise available or when unavailable locally the LMIC has recruited external experts such as clinicians (radiation oncologist and medical physicist), architects, building contractors and engineers to design, construct and commission the new radiotherapy service in accordance with all regulatory requirements.
	Access to suitable land	35. The LMIC has secured suitable site for the radiotherapy service 36. The LMIC has successfully conducted environmental and engineering hazard assessments to mitigate natural disaster and engineering risks.
	Construction of the building	37. The LMIC has identified and secured the services of experienced contractors to complete the building and bunker(s) for housing the radiotherapy equipment according to specifications and project timelines
	Equipment purchase, delivery and set-up	38. The LMIC has contracted a vendor for optimal equipment purchase (teletherapy and brachytherapy with applicators), timely delivery and installation, as well as oncology-specific patient information management software and other accessory equipment, such as planning systems, simulation machine, dosimetry devices and immobilisation devices. 39. The LMIC has made arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment.
	Training for initial core staff	40. The LMIC has identified candidates for radiotherapy leadership positions and arrangements have been made to train all staff to form the core workforce – radiation oncologists, radiation therapists, medical physicists and cancer care nurses. 41. The LMIC has made arrangement for onsite vendor training and/or participation in an international mentorship programme for specific clinical education and training. 42. The LMIC has a plan to ensure that immediate staff education and training are undertaken in centres with patient populations, equipment and training programmes relevant to the needs of the LMIC.
	Other supporting staff	43. The LMIC has appropriately identified and trained other supporting staff such as social workers, dieticians, occupational therapists, information technologists and case managers or coordinators.
	Staff succession plan	44. As part of a scale-up implementation strategy, the LMIC has a long-term strategic plan for building in-LMIC radiotherapy specific academic and clinical education capacity to ensure the continuous development of radiotherapy workforce

Domain	Requirements	Criteria
		locally while addressing concerns about expected staff annual leave, retirement, change in jobs and brain drain due to overseas benefits.
		45. The LMIC has knowledge of staffing needs and plans to articulate with regional professional networks and participate in regional e-learning programmes for continuous professional development to address staff knowledge and skill gaps.
	Incentive systems	46. The LMIC has made arrangement for suitable financial and non-financial incentive packages for staff, including appropriate salaries to motivate and retain staff.
	Service contract	47. The LMIC has a contractual service agreement for the purchased equipment to enable timely engineering support to minimise downtime. 48. The LMIC has arranged to select and train a team of in-house engineers as part of the procurement plan.
	Spare parts	49. The LMIC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including the availability of spare parts and training of engineers. 50. The LMIC has made arrangement to generate funds through service charges or government revenue to support the radiotherapy service maintenance over the long-term period, including purchasing of spare and repair parts and replacement of obsolete equipment. 51. AC: The LMIC has created favourable trade and border legislation that encourage compliance and eliminate procedural barriers to medical goods across the border.
	Governance and management structure	52. The LMIC has created an inclusive governance and management board plan for the new radiotherapy service to ensure there is participation in higher-level decision-making, strategic direction, financial and clinical governance, such as being accountable to patients and their families. 53. AC: The LMIC has created a plan to ensure that the radiotherapy service articulates with other cancer services, such as diagnostics, medical oncology, and palliative care.
	Treatment guidelines, protocols and standard operating procedures	54. The LMIC has made arrangement to develop radiotherapy guidelines, protocols, standard operating procedures or has a plan to adopt international standards to guide the best practice of radiotherapy.

Domain	Requirements	Criteria
	Other essential health services	55. The new radiotherapy service has other essential health services available, such as radiological (computerized tomography [CT] scan, Magnetic Resonance Imaging [MRI] and ultrasound scan), laboratory and nuclear medicine on-site or the LMIC has taken steps towards outsourcing such services from nearby health services.
	Social support services	56. The LMIC and/or civil society organisations have programmes in place to provide social support services for patients, such as transport, accommodation assistance scheme, dietary support and information services.
	Generate, compile, analyse and communicate health data	57. The LMIC has a basic health information system in place to collect clinical and non-clinical information in formats that meet the dissemination and communication needs of care providers, managers, patients and families to aid decision-making. 58. The LMIC has well-trained information technologists to implement appropriate safeguards to protect patient data confidentiality.
Catalyst	Encourage cancer control reform	59. The LMIC has identified that the new radiotherapy service will help the LMIC meets its cancer control goals and ready to act on an opportunity to improve equity in cancer control. 60. The LMIC has plans to use the new radiotherapy service as a window of opportunity to promote and mobilise resources to develop a comprehensive service and optimise all aspect of cancer control (prevention, diagnosis, treatment and palliative care). 61. The LMIC has plans to use the new radiotherapy service to and sensitize policy-makers and health authorities about the growing burden of cancer and the importance of integrated cancer control strategies for managing it.
	Promote coordinated care	62. If possible, the LMIC has plans to use the new radiotherapy service to upgrade information systems to improve coordination of care across providers, services and settings. 63. The LMIC has plans to use the new radiotherapy and/or other services to develop patient referral pathways and registries to increase transition across specialists. 64. Using nurse coordinators, the LMIC has plans to support patients as they navigate the complex cancer treatment and care pathway.
	Promote a multidisciplinary approach to care	65. The LMIC has plans to use the new radiotherapy service to advocate for the promotion and implementation of multidisciplinary team management of cancer patients.

Domain	Requirements	Criteria
		66. As a window of opportunity, the LMIC has plans to use the new radiotherapy service to facilitate the development and implementation of national cancer management guideline in collaboration with other specialities.
	Strengthen patient- and family-centred care	67. The LMIC has plans to use the new radiotherapy service to provide patients and families access to basic information about cancer management and self-management support outside the healthcare setting through nurse coordinators or the internet. 68. The LMIC has plans to use the new radiotherapy service to develop educational and skill-building programmes for patients and families on the management of cancer. 69. Through collaboration, the LMIC has plans to use the radiotherapy service to better meet the needs of cancer patients (example, transport, accommodation and food is an incentive for low-income patients to adhere to treatment). 70. The LMIC has plans to use the new radiotherapy service to develop written and online patient education materials to support self-management strategies, which could be adopted by other LMICs. 71. The LMIC has plans to use the new radiotherapy service to build a stronger connection with community organisations to promote awareness and use of radiotherapy.
	Encourage better outcomes through research	72. The LMIC has plans to use the new radiotherapy service to emphasise the importance of evidence-based cancer care and the need to implement cancer registry through partnerships. 73. The LMIC has plans to use the new radiotherapy service to support the conduct of local research to produce and demonstrate the cost-effectiveness of innovative care and strategies 74. The LMIC has plans to use the new radiotherapy service to establish international and regional collaborations where radiotherapy centres can exchange information, share expertise, policies and strategies to improve services.

AC – Additional criteria that emerged from participants’ comments; Bold texts indicate major modifications to a requirement or criterion based on participants’ comments; LMIC – low and middle-income country; and Global Cancer data – GLOBOCAN

6.7 Discussion

The participant validation process has confirmed 37 requirements and 74 criteria that ought to be considered for inclusion in a radiotherapy service development readiness self-assessment guide for use by LMICs establishing or planning to establish safe and sustainable new radiotherapy services. While there are no definite formula to promote the establishment of a successful radiotherapy service, the proposed readiness self-assessment guide includes a series of requirements that LMICs planning to establish safe and sustainable radiotherapy services ought to be aware of and consider from the outset of the planning process. The 37 requirements and 74 criteria provide practical guidance across the following four key readiness domains, namely: *'commitment; cooperation; capacity; and catalyst'*, which are discussed below (refer to Figure 6.1).



Figure 6.1: Conceptual overview of readiness requirements across the four domains required for establishing radiotherapy services in LMICs

Commitment

Commitment is a fundamental requisite for success when establishing a new radiotherapy service. Stable and safe political environment within an LMIC is important because it enables the continuity and coordination of government policies. A stable and safe political environment also creates favourable conditions for the development and effective functioning of civil society organisations to provide leadership and advocacy campaigns important in gaining political support to establish a radiotherapy service. The data indicate that attracting long-term financial investment from international banks and gaining technical assistance to establish a new radiotherapy service occurred within a stable political environment. The data also identified that availability and accessibility of adequate and quality infrastructure services, such as roads, water, electricity and sewerage systems are critical to support a radiotherapy service establishment. For example, the quality supply of electricity remains limited in most LMICs. Therefore, there ought to be a plan for backup power to ensure a consistent supply of electricity. Recognising government infrastructure policy initiative is equally vital to ensuring that road networks link to the radiotherapy service centre and that quality water supply is availability.

Advocating for increased political commitment to improve access to quality and equitable radiotherapy services can be complex. Advocacy can bring about positive results when constructively applied. Civil society organisations, healthcare professionals, political leaders and community leaders are influential vision champions that could serve as advocates for a radiotherapy service initiative. Vision champions are vital for actively engaging and influencing senior political leaders to create support to improve access to radiotherapy services. Vision champions combined social networking, interpersonal communication, negotiation and supportive evidence to increase advocacy. Exploiting windows of opportunity is vital to building and/or maintaining political support for funding, policy and institutional commitments to establish a radiotherapy service. Media campaigns, lobbying actions and framing the issue effectively by credible spokespersons are examples of proven advocacy strategies in health that can persuade governments to initiate actions to develop cancer control policies (Hancher-Rauch, Gebru & Carson 2019; Servaes & Malikhaio 2010).

Cancer control policy that has been approved by a Ministry responsible for health is pivotal in mobilising and allocating resources. However, the concern that most developed cancer control plans in LMICs are not implemented because of lack of: funding; expertise; and technical support have been highlighted in the literature (Pearlman et al. 2016; Romero et al. 2018). Embedding a radiotherapy service implementation plan into the country-wide cancer control policy is seen as vital to ensuring that financing was not fragmented, and integrated cancer care is strengthened. It is considered important for the cancer control plan to be costed and measurable to ensure the continuation of essential actions.

The participant validation process has confirmed that the planning, developing, implementing and monitoring of a radiotherapy service is dependent on reliable and accurate data. The required data included cancer incidence and mortality data from a population-based or hospital-based cancer registry. However, common challenges in most LMICs included: the lack of accurate cancer data to determine optimal equipment and facility siting; and inadequate expertise to gather and organise data about epidemiology (Donkor et al. 2020). As a result, planning of radiotherapy services is usually based on extrapolated global cancer GLOBOCAN data that may not be particularly reliable. The LMIC's action plan to develop a cancer registry through collaboration and support of International Agency for Research on Cancer Global Initiative for Cancer Registry Development is vital.

Financing model is crucial because it is the mechanism by which plans to establish a new radiotherapy service translates into reality. However, financing a radiotherapy project in any LMIC can be challenging, so often the suggestion is to secure a long-term budgetary commitment from diverse sources. It is critical to take into consideration public, private and/or philanthropic financial commitments in support of the radiotherapy project (Donkor et al. 2018). Developing a business case is critical because it allows the LMIC to illustrate how and when efforts to invest in a radiotherapy service will pay off. That is, a business case is used to justify investment in a radiotherapy service. It is therefore important that the ministry responsible for health collaborate with their financial colleagues to understand and develop a strong business case for a radiotherapy service development.

Achieving a safe and sustainable radiotherapy service requires effective legal and regulatory framework. Effective legal and regulatory framework is critical to the success of a radiotherapy service because it helps define the scope of practice, technical requirements and operational procedures to safeguard the use of ionising radiation. Developing and enforcing a regulatory framework is also critical to protect the rights of cancer patients, training and importation of healthcare professionals to meet radiotherapy workforce skill gaps. It was evident from the data that having an independent country-level regulator is vital to provide supervisory oversight. Independent regulator ought to inspect, authorise actions and enforce the legislation and regulations to prevent accidents, control hazards and respond to emergencies. Also, an independent regulator is critical to ensure compliance with international standards of radiation safety, security and protection.

Cooperation

In establishing safe and sustainable radiotherapy services, it is essential to consider stakeholder cooperation leading to a collective action. There are three cooperation requirements of importance that LMICs ought to consider: strategic planning team; stakeholder involvement; and technical assistance plan. Members of the strategic planning team ought to have the right mix of skills, knowledge and experience to undertake and oversee the planning of

the radiotherapy service. The strategic planning team has responsibilities such as: conducting a need assessment, environmental hazard assessment and feasibility studies. It is important to recognise that the strategic planning team could consist of technical working groups or sub-committees with the specialty. The strategic planning team ought to ensure that there is a smooth articulation between the radiotherapy service and any existing cancer services in the LMIC. A strategic planning team that recognises and appreciate the advantage of understanding the LMIC's current capacity helps align activities and available resources. It is imperative to place greater emphasis on identifying and involving relevant stakeholders to enrich the radiotherapy service development planning effort.

Capacity

The findings from the participant validation process confirm that understanding LMICs' capacity is crucial for the successful establishment of safe and sustainable radiotherapy services (Donkor et al. 2020). Constraints on capacity can exert a negative impact on radiotherapy services in LMICs (Grover et al. 2014). Capacity requirements to ensure successful radiotherapy service establishment address implementation resources and activities, workforce development, regular maintenance, leadership, other essential and complementary services and information systems. The key to creating a radiotherapy service implementation team is to ensure that the required expertise and knowledge exists within the team. The objectives of the implementation team are to manage and accomplish the day-to-day tasks and activities of the radiotherapy project at exceptionally high levels of performance once the radiotherapy service implementation plan has been approved at the ministerial level. The members of the implementation team ought to collaborate over time to achieve the radiotherapy service implementation goals.

Most projects to establish safe and sustainable radiotherapy services in LMICs fail to deliver because of lack of expertise such as architects, building contractors, engineers and medical physicists. Therefore, conducting needs and readiness assessments are critical because they help the LMIC determine the gaps that could prevent it from achieving its radiotherapy service development goals. The assessment ought to determine what the important needs are and how the LMIC can address them to be ready and stay successful. The needs and readiness assessments can help the LMIC to align resources with strategy and provide data for radiotherapy service decision making. For example, after a need assessment, consideration ought to be given to recruiting experts when unavailable locally to design, construct, set-up equipment and commission the radiotherapy equipment in accordance with all regulatory requirements. The needs and readiness assessments can also help the LMIC identify leverage points and resources as well as determine stakeholders who ought to be involved when establishing safe and sustainable radiotherapy services.

Catalyst

The findings from the participant validation process confirm that LMICs can take advantage of radiotherapy services to improve access to integrated service and optimise all aspect of cancer control, including palliative care. Therefore, catalyst requirements address LMICs looking at radiotherapy services as health investment that can: facilitate the harmonisation of cancer care, drive the orientation of cancer care around people living with cancer and their families; and support the building of oncology research capacity. Several strategies, such as a multidisciplinary team ought to be implemented to ensure that the care for people living with cancer is quality and patient-centred. Use of clinical guidelines, engagement and empowerment of cancer patients and access to information for the multidisciplinary cancer care team and people living with cancer underpin patient-centred cancer care.

The participation validation process has successfully confirmed the relevance of several readiness requirements and criteria that could be used to determine LMICs progress to establish safe and sustainable radiotherapy services. However, there are still gaps that require further field research to refine the understanding of the readiness requirements and criteria and the conditions under which they are predictive and informative. The findings of the participant validation process could be used as a guide to help LMICs obtain objective information to address challenges related to establishing a new radiotherapy service by making well-informed decisions and aligning budgets. The findings are not meant to be used as a checklist or substitute in-LMIC expert advice. Rather, it is intended that the guide be used to engage effectively in a range of collaborative discussions with diverse stakeholders to ensure a sustainable and cost-effective radiotherapy project.

6.7.1 Strength and limitations

The strengths of Study Two [Part B] include allowing a broader end-user engagement and participation (experience of both international and local experts) in generating and confirming requirements. This ensures that the readiness self-assessment guide meets usability and practical needs of LMICs. The inclusive validation process allowed for the generation of new ideas and alternative explanations for a more comprehensive set of requirements and criteria. However, these readiness domains and requirements should be field-tested in a larger, more representative sample. The sample size was limited by the arduousness of participation given the large number of requirements and complexity of tasks. The revised requirements and criteria were not revalidated by participants. Future study will pilot the requirements and criteria in order to inform further refinement.

6.8 Conclusions

Establishing a safe and sustainable radiotherapy service is a complex task and unplanned efforts can be expensive and futile. A readiness assessment is a step often omitted when

establishing safe and sustainable radiotherapy services in most LMICs. Investing a day or two stakeholders consultative workshop guided by a readiness self-assessment guide may guide decisions on resource allocations to achieve radiotherapy service implementation and sustainability goals.

6.9 Summary

This Chapter has presented the findings of the participant validation process (Study Two [Part B]). The participant validation process has confirmed a set of 37 requirements to provide practical guidance for appraising LMICs' readiness to establish safe and sustainable radiotherapy services. In the next Chapter, the ARC Project data integration and final end-point meta-inference will be reported, answering each of the ARC Project's research questions. The Chapter will also present the first version of the readiness self-assessment guide for LMICs establishing safe and sustainable radiotherapy services, which will be made available for LMICs to use and, it is hoped, will be further refined through its use.

6.10 Reference

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Chapter Seven: Conclusion and Implications

7.1 Overview

Chapter One outlines how the lack of radiotherapy services in LMICs impacts adversely on cancer care outcomes. It also described the challenges of establishing a new radiotherapy service, which is amplified for many LMICs by their lack of resources, skills, knowledge and radiotherapy project management expertise (Donkor et al. 2020b). Given these challenges, the rationale for using the WHO's Innovative Care for Chronic Conditions Framework and the Health System Building Blocks Framework for Action is also provided in Chapter One (WHO 2007; WHO 2002).

The systematic review (Study One) reported in Chapter Two identified a range of strategies designed to increase access to cancer treatment and palliative care services in LMICs. However, few studies had considered the strategies required for establishing or strengthening access to radiotherapy services in LMICs (Donkor et al. 2018).

Chapter Three described the ARC Project's pragmatic sequential mixed qualitative methods design. It also details the two-part qualitative study undertaken, including: Study Two [Part A] a series of semi-structured interviews with global radiotherapy experts recruited through purposive and snowball sampling techniques; and Study Two [Part B] a participant validation process, which consisted of radiotherapy service development readiness domains/requirements: generation; confirmation; and revision. It also details the integration of the various data sets, and the mid-point and end-point meta-inference used to answer each of the ARC Projects three research questions.

Chapter Four presents the findings emerging from the semi-structured interviews undertaken with global radiotherapy experts (n=17) (Study Two [Part A]). It details the significant barriers to establishing safe and sustainable radiotherapy services in LMICs, as well as the facilitators that could be harnessed to deliver better cancer outcomes for people living in these underserved communities.

Chapter Five reports on the mid-point meta-inference, which integrates the data from the systematic review (Study One) and semi-structured interviews (Study Two [Part A]) to generate a list of potential requirements that need to be considered if LMICs plan to establish safe and sustainable radiotherapy services. These requirements were converted into a potential guidance list for use at the country/policy (macro) or service (meso) level to assess the LMICs' readiness to establish safe and sustainable local radiotherapy services. These requirements were subsequently confirmed, refuted or modified during the participant validation study (Study Two [Part B]). The findings of the participant validation study are presented in Chapter Six and framed as readiness requirements and criteria that could feasibly be used to assess LMICs' readiness to establish safe and sustainable radiotherapy services.

In this final Chapter, the ARC Project data are integrated to answer the research questions asked in Chapter One. The integration and end-point meta-inference of the entire ARC Project's data allows for a series of implications relating to policy, practice and research to support expanding access to radiotherapy services in LMICs to be made. The final section of this Chapter presents the '**RE**adiness **SE**lf-Assessment (RESEA) Guide' for LMICs establishing safe and sustainable radiotherapy services and considers next steps for its further refinement.

The methods for integrating the ARC Project's data and end-point meta-inference has been described in Chapter Three. The following sections answer the ARC Project's three research questions.

7.2 Research Question One: What efforts have been made to improve cancer care in LMICs and how effective have they been?

As detailed in the ARC Project's systematic review reported in Chapter Two, of the 19 included studies, it was evident that significant efforts have been made to improve cancer care in LMICs over the past three decades with several implementation barriers and facilitators in accordance with the WHO's Innovative Care for Chronic Conditions Framework.

The ARC Project's systematic review identified that positive policy environment in some LMICs has supported the building of multi-sectoral partnerships into a variety of strategies to improve cancer care in LMICs. Multi-sectoral partnerships among governments, civil society organisations and/or private sector often influence the financing of strategies to improve cancer treatment and palliative care. It was recognised imperative to meaningfully engage relevant stakeholders to maximise the benefits of multi-sectoral partnerships (Donkor et al. 2018).

Efforts toward promoting sustainable cancer care workforce were identified in the ARC Project's systematic review. Tele-education and 'train-the-trainer' initiatives by organisations such as Radiating Hope have greatly advanced the development and allocation of radiotherapy workforce in most LMICs (Donkor et al. 2018; Einck et al. 2014). Another critical effort identified in the ARC Project's systematic review was international research collaborations to optimise cancer data collection, analysis and dissemination in LMICs. Collaborative research capacity-building activities identified included: training; training; advocacy; provision of resources; and technical assistance to design and implement cancer registries (Donkor et al. 2018).

The healthcare organisation and community-based strategies described in the literature ranged from incentive schemes, coordinated care, physical infrastructure programmes to equip cancer care teams, information management systems, community volunteering programmes and community healthcare workers (Donkor et al. 2018). Community mobilisation efforts involving community leaders and civil society organisations often: provide leadership and advocacy; promote consistent financing; organise and equip healthcare professionals, with the necessary equipment and essential medicines (Donkor et al. 2018).

Unfortunately, the effectiveness of the identified strategies in the ARC Project's systematic review has not been robustly evaluated in any of the included studies. Consequently, the impact of the efforts to improve cancer care in LMICs are unknown and much remains to be learned.

Few of the identified studies (n=4) focused on radiotherapy services (Donkor et al. 2018) and those that did were of poor quality and provided limited insights or guidance to LMICs about the most effective strategies to employ when planning and/or sustaining radiotherapy services in under-resourced settings. This lack of evidence and/or guidance highlighted a need to identify and understand the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, and to determine the degree to which the strategies used to improve other aspects of cancer care could be adopted by radiotherapy services. Understanding this was considered essential to providing guidance that could assist policy makers, planners and implementers to adopt the most context-appropriate strategies or solutions.

7.3 Research Question Two: What are the barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs?

As described in the mid-point meta-inference reported in Chapter Five, several barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs were identified. Supportive policy environment was essential for creating and maintaining a strategic vision of establishing sustainable and safe radiotherapy services in LMICs. The ARC Project's mid-point meta-inference identified that epidemiological data and integrated cancer control policy challenges are enduring in most LMICs, which require a coordinated strategy that reflects LMICs needs and explains the roles and responsibilities of international agencies/organisations, such as International Agency for Research on Cancer, IAEA, UICC and Pan American Health Organisation in designing, implementing, sustaining and scaling-up cancer registries (Bray et al. 2014; Donkor et al. 2018; Donkor et al. 2020b).

Another three common problems at the macro-level were: the lack of legislative and regulatory framework for enhancing the quality of radiotherapy services; the failure to mobilise the necessary financial resources; and the lack of political leadership commitment to expand access to radiotherapy services (Donkor et al. 2018; Donkor et al. 2020b). However, the availability of local champions was a critical factor in providing leadership, awareness and advocacy to influence senior political leaders to allocate the necessary resources for the establishment of safe and sustainable radiotherapy services (Donkor et al. 2018; Donkor et al. 2020b).

Several challenges to establishing safe and sustainable radiotherapy services in LMICs were evident within the meso-level of healthcare and community, including: inadequate stakeholder engagement; lack of a project manager; weak contract negotiations with powerful vendors; inability to organise and equip radiotherapy workforce to deliver quality and safe radiotherapy

services; lack of information and communication technologies for coordinated, integrated and evidence-informed radiotherapy services; lack of radiotherapy equipment maintenance strategy; and poor governance and lack of transparency (Donkor et al. 2018; Donkor et al. 2020b). In contrast, the ARC Project's mid-point meta-inference revealed that education and training of radiotherapy workforce is crucial and international agencies/organisations have been providing opportunities, such as provide peer-to-peer support, online learning resources, information sharing and hands-on in-country fellowships (Donkor et al. 2018; Donkor et al. 2020b).

Nurses are important stakeholders who should be actively involved in the development of radiotherapy services in LMICs. One of the most important roles nurses can play is that of political advocacy, which can take many forms, including: stakeholder awareness of the importance of radiotherapy; and participation in advocacy that targets national cancer plans and policies to promote equity in cancer care (Truant 2017).

7.4 Research Question Three: What readiness requirements do LMICs need to consider when setting out to establish safe and sustainable radiotherapy services?

The final research question is answered through an end-point meta-inference of the ARC Project's three data sets (refer to Table 7.1 for the joint display table).

Emerging from the ARC Project's end-point meta-inference are several requirements that are related to the four key readiness domains, namely: commitment; cooperation; capacity; and catalyst. Each of these requirements needs to be given due consideration when setting out to establish safe and sustainable radiotherapy services in LMICs, as detailed below.

7.4.1 Commitment-related requirements

The confirmatory findings revealed that a safe, stable and supportive political environment enables senior political leaders to decide and commit the necessary resources to support the establishment of safe and sustainable radiotherapy services. Adequate and high-quality basic physical infrastructure ranging from a consistent supply of electricity, water and road transport networks were confirmed relevant because they have effect on cancer patients' ability to use radiotherapy service as well as efficiently maintain the radiotherapy equipment (Donkor et al. 2018; Donkor et al. 2020b).

Local champions identifying opportunities for advocacy to influence senior political leaders and other stakeholders to mobilise and allocate the necessary resources to establish safe and sustainable radiotherapy services was confirmed crucial due to the misconception that investment in safe and sustainable radiotherapy services in LMICs is not relevant. The findings affirmed that developing an integrated cancer control policy that is based on a reliable epidemiological data with a clear vision, timeline and budget helps leaders to align, manage and prioritise resources to minimise fragmentation in funding and cancer care services.

The ARC Project's end-point meta-inference reinforced the importance of identifying and securing a long-term financial commitment from diverse funding sources ranging from public, private, charity and/or multi-sectoral partnerships when establishing safe and sustainable radiotherapy services in LMICs. It also highlighted the value in political commitment towards achieving universal health coverage to ensure cancer patients accessing radiotherapy services do not suffer financial hardship when paying for them (Donkor et al. 2018; Donkor et al. 2020a, 2020b). LMICs establishing membership with IAEA was confirmed as the primary contributor to securing technical assistance to develop a legislative and regulatory framework as well as dosimetry and training support to establish safe and sustainable radiotherapy services (Donkor et al. 2020a, 2020b). Similar to other studies in health (DiClemente, Schlundt & Gemmell 2004; Ghazisaeidi et al. 2014; Weiner 2009), the findings from the ARC Project's end-point meta-inference acknowledged that commitment is the most important pre-requisite and securing it early from the beginning of the process is crucial for achieving successful establishment of safe and sustainable radiotherapy services.

7.4.2 Cooperation-related requirements

The ARC Project's end-point meta-inference confirmed the critical role of cooperation requirements to ensuring adequate strategic planning process and design of safe and sustainable radiotherapy services. It confirmed the importance of developing a plan to map and analyse stakeholders (both local and international) based on their impact, interest and influence because it enables the identification and engagement of key supporters, potential saboteurs and advocates. In the current City Cancer Challenge initiative, stakeholder engagement has been noted to help enhance local champions' support across multiple sectors such as government, civil society and private sector while giving visibility, credibility and momentum to implement the initiative (Morton, Henshall & Aranda 2019). Subsequently, it was identified that stakeholder mapping and analysis provide a mechanism to manage stakeholders contributions, relationships, expectations and power to ensure early buy-in and ownership when planning to establish safe and sustainable radiotherapy services (Donkor et al. 2018; Donkor et al. 2020a, 2020b).

The confirmatory findings highlight the importance of creating a strategic planning team to cooperatively plan and decide on issues such as equipment type, siting of the radiotherapy centre, funding for the radiotherapy service and radiotherapy workforce training based on credible and valid analysed data and information shared with the planning team (Donkor et al. 2018; Donkor et al. 2020a, 2020b). In addition to forming the strategic planning team, the end-point meta-inference confirmed the importance of identifying approaches that could help translate the strategic plans into actions. These findings are crucial because there is considerable evidence that shows that a larger proportion of LMICs are unable to implement their strategic plans to improve access to radiotherapy services and other cancer care services

because they are not adequately funded or lack of political will (Romero et al. 2018; Stefan et al. 2013; WHO 2020).

The ARC Project's end-point meta-inference also confirmed the importance of developing a technical assistance plan based on the need for resources and support identified in the LMIC's a need assessment and strategic planning process. As highlighted in other studies (Einck et al. 2014; Fisher et al. 2014; Morton, Henshall & Aranda 2019), the findings confirm the need to develop solutions that reflect the unique local context to help minimise risks.

7.4.3 Capacity-related requirements

The ARC Project's end-point meta-inference confirmed the importance of several capacity requirements for the effective implementation of safe and sustainable radiotherapy services. Forming a multidisciplinary implementation team and appointing a responsible project manager were critical capacity requirements to operationalise and help coordinate the day-to-day management of the radiotherapy service implementation activities, including: equipment purchase, delivery, installation, acceptance testing, commissioning, licensing and training. Project management was confirmed be a critical method for driving the radiotherapy service development process and changes needed for successful implementation. Similar to studies in health and community development (Emel, Makene & Wangari 2012; Nyaguthii & Oyugi 2013; Payne et al. 2011), the importance of bringing the necessary skills, knowledge and adequate resources to turn the vision of establishing a safe and sustainable radiotherapy service into a successful outcome was revealed.

It was confirmed that embedding an appropriate plan to provide training and education for the radiotherapy workforce makes it possible to operationalise, deliver and sustain radiotherapy services (Donkor et al. 2018; Donkor et al. 2020a, 2020b). It is therefore important that ministries responsible for health, education and finance are coordinated and able to work together to develop a training strategy that is appropriate for radiotherapy workforce to deliver safe treatment.

In order to ensure challenges, such as cost of spare parts, unavailability of spare parts and unqualified local engineers were addressed, it is essential to develop a maintenance plan, quality assurance plan and service contract. It also reinforced that creating an inclusive governance and management board structure was essential to provide adequate oversight responsibility for the radiotherapy centre. Developing treatment guidelines, protocols and standards operating procedures is critical to support quality cancer care through scientific evidence (Donkor et al. 2020a, 2020b).

7.4.4 Catalyst-related requirements

The ARC Project's end-point meta-inference reinforced the significance of a range of catalyst requirements that contribute to strengthening integrated cancer care. It confirmed that developing and implementing information and communication technologies promote continuity and coordination of care among cancer specialists. Additionally, integrating information and communication technologies into the establishment of safe and sustainable radiotherapy services also allows follow-up visits to be scheduled and organised effectively for cancer patients (Donkor et al. 2018; Donkor et al. 2020a, 2020b). This finding is reflected in the international literature, which indicates that the expansion of information technology offers new avenues that could be exploited to make radiotherapy services and integrated cancer care available in LMICs through tele-networking (Datta & Rajasekar 2004).

In order to support optimal management of cancer patients, it is essential to establish a multidisciplinary team to share information and plan their treatment and care. While the challenge of establishing a multidisciplinary team was noted in the ARC Project, global radiotherapy experts perceived that identifying a care coordinator within the multidisciplinary team was essential to ensuring that efforts of all involved cancer specialists and other healthcare professionals are coordinated and integrated (Donkor et al. 2020b). It was confirmed that the availability of a radiotherapy service provides opportunities for creating international and/or regional research collaborations. Maintaining informal and formal network relationships was revealed as an important requirement for achieving success in a research collaboration between radiotherapy centres in LMICs and HICs (Donkor et al. 2018; Donkor et al. 2020a, 2020b).

Table 7.1: Joint display table representing data integration, convergence and inference for Research Question Three

Research Question Three: What readiness requirements do LMICs need to consider when setting out to establish safe and sustainable radiotherapy services?			
Mixed methods from Study One (systematic review) and Study Two [Part A] (semi-structured interviews) Inferences summarised based on Research Question Two	Qualitative data from Study Two [Part B] (participant validation)	Data convergence	Endpoint meta-inference
Gaining commitment to a vision to establish a new radiotherapy service requires factors such as	The participants identified and confirmed several commitment requirements that are relevant when establishing a radiotherapy service in LMICs, including		
Political environment that is conducive to supporting a radiotherapy service. The absence of a political conflict nurtures an environment that allows financial investment in healthcare, including radiotherapy service.	Stable political environment was endorsed as relevant because it helps attract both long-term financial investment and international technical assistance.	Confirm	There is a safe, stable and supportive political environment that enables political leaders to decide and commit the necessary resources to support the establishment of a radiotherapy service.
Adequacy of physical infrastructure such as road transport network, reliable supply of electricity and water directly support the process of operating and cancer patients accessing the radiotherapy service.	Quality basic physical infrastructure was identified as critical and there ought to be a plan to construct sewerage system.	Confirm	There is adequate and high-quality physical infrastructure ranging from a consistent supply of electricity to road transport networks to support the decision to establish a radiotherapy service.
Awareness and advocacy to create critical consciousness about the radiotherapy service access problems and build a sense of urgency among relevant stakeholders to mobilise and allocate the necessary resources to establish a radiotherapy service.	Opportunity for advocacy was highly endorsed as important influence on political leaders and decision-makers.	Confirm	There are vision champions available to raise awareness and advocate to influence senior political leaders and other stakeholders to commit the necessary resources to establish a radiotherapy service.
Availability of an integrated cancer control policy that is developed based on accurate epidemiological data is beneficial to minimise fragmentation.	Cancer control policy was unanimously confirmed as essential to inform allocation of necessary resources.	Confirm	Developing an integrated cancer control policy that is based on a reliable epidemiological data with a clear vision, timeline and budget helps leaders to align, manage and prioritise

resources to minimise fragmentation in cancer care.

There is a budgetary decision and long-term financial commitment from government, private sector, charities and/or multisectoral partnerships.

There is political commitment towards achieving universal health coverage to ensure cancer patients accessing radiotherapy services do not suffer financial hardship when paying for them.

Evidence of membership with IAEA is the primary contributor to technical assistance to develop legislative and regulatory framework and other actions to establish a safe and quality radiotherapy service.

There is a plan to map and analyse stakeholders (both local and international) by impact, interest and influence to identify and engage key supporters, potential saboteurs and advocates.

There is a strategic planning team to cooperatively plan and decide on issues such as equipment type, location, funding and radiotherapy workforce training based on credible and valid analysed data and information shared with the team.

Building capacity to implement and sustain the radiotherapy service requires factors such as		The participants identified and confirmed several capacity requirements that are relevant when establishing a radiotherapy service in LMICs, including		
Identifying a project manager with technical and relevant knowledge and experience helps coordinate the implementation activities.	Forming a multidisciplinary implementation team that is responsible for the day-to-day management of the radiotherapy service building, equipment installation, commissioning and licensing was confirmed relevant to avoid delays.	Confirm	In order to operationalise the radiotherapy service implementation plan on time, budget and high-quality, a multidisciplinary implementation team led by a project manager has been formed.	
Appropriate training and education for the radiotherapy workforce ensures cancer patients receive optimal treatment.	Developing a plan to ensure that radiotherapy workforce (both core staff and other supporting staff) are timely trained in an appropriate institution was endorsed as relevant to prevent underutilisation of the radiotherapy equipment.	Confirm	There is arrangement to provide training and education for radiotherapy workforce to make it possible to operationalise and maintain the radiotherapy service.	
Carefully negotiating with a vendor for a service contract, spare parts supply and engineering support ensures maintenance of the radiotherapy equipment.	Availability of service contract and spare parts were confirmed important to ensure maintenance and equipment reliability.	Confirm	There is a maintenance plan that involves a range of activities such as service contract management, spare parts supply and training for local engineers for appropriate radiotherapy service operation.	
Governance and management provide oversight of actions such as financing, contracts and clinical activities.	Creating an inclusive governance and management board structure was confirm relevant to ensure there is participation in higher-level.	Confirm	There is an inclusive governance and management board that represents and advances the radiotherapy centre and are responsible for the performance of the radiotherapy centre.	
Adopting an evidence-based practice provides LMICs the opportunity to use critical appraised and scientifically developed evidence for delivering quality radiotherapy services to cancer patients.	Developing treatment guidelines, protocols and standards operating procedures was endorsed as relevant to guide best practice of radiotherapy services.	Confirm	There is an arrangement to ensure the development of treatment guidelines, protocols and standard operating procedures to encourage quality cancer care through scientific evidence.	
Strengthening integrated cancer care through a radiotherapy service requires factors such as		The participants identified and confirmed five catalyst requirements that are relevant when establishing a radiotherapy service in LMICs, including		
Availability of information and communication technologies enable	Implementing information and communication technologies was confirm essential to collect clinical and non-clinical information in formats that	Confirm	Information communication and technologies are available to improve standard of cancer care. There is an effective action plan that will	

cancer patients and cancer specialists to connect and/or communicate.	meet dissemination and communication needs of cancer care providers and cancer patients.		leverage the available information and communication technologies to promote continuity and coordination of cancer care.
Research collaborations enable sharing of information, expertise and policies to improve radiotherapy services.	Using the established radiotherapy centre to build international and/or regional research partnerships was confirmed relevant to produce and demonstrate the cost-effectiveness of innovative radiotherapy treatment techniques.	Confirm	The established radiotherapy service creates opportunities for the LMIC to leverage their relationships through international and/or regional research collaborations to improve radiotherapy service delivery.
Establishing a multidisciplinary team of cancer care specialists that continually assesses, evaluates and plans cancer patients' care.	Promoting a multidisciplinary approach to cancer care was confirmed essential to enable decisions are documented and discussed.		Establishing a multidisciplinary team ensures cancer patients receive optimal management of their treatment and timely referral as needed.

Legend: Confirm – the current study reinforces the findings of the previous study; Enhance – the current study further improve the findings of the previous study; New – the current study provides findings not existing before in the previous study

Summary

The section above has reported the integration and end-point meta-inference of the ARC Project's data, which answers the three research questions. The next section presents the details about the **RE**adiness **SE**lf-**A**ssessment (RESEA) Guide' for LMICs establishing safe and sustainable radiotherapy services.

7.5 The RESEA Guide for LMICs establishing safe and sustainable radiotherapy services

An important output of the ARC Project's research is the development of the RESEA Guide for LMICs to use when embarking on the establishment of safe and sustainable radiotherapy services. The RESEA Guide is underpinned by the ARC Project data and helps policy-makers, planners and clinical leads to focus on the readiness domains and the requirements considered most important to the establishment of safe and sustainable radiotherapy services in LMICs (Donkor et al. 2018; Donkor et al. 2020a, 2020b).

The need for such a guidance document is reflected in the ARC Project's end-point meta-inference, which revealed that 'conceiving a vision' to establish a safe and sustainable radiotherapy service is only the beginning of the narrative, and not an end of itself. The ARC Project's end-point meta-inference strongly suggests that establishing safe and sustainable radiotherapy services is complex and nuanced. This complexity demands consideration of a diverse range of environmental, political, health care systems, financing and operational factors, many of which need to be considered concurrently and require long-term planning.

A study to develop a 'checklist' to help standardise the implementation process of new radiotherapy equipment in LMICs found that 10 requirements are critical to consider, including: site and resource assessment; evaluation of equipment and funding; establishing timelines; defining the treatment process; equipment quality assurance and commissioning; training and competency assessment; prospective risk analysis; system testing; external audit; and follow-up support (Brown et al. 2014). Building on the existing literature, the RESEA Guide focuses on naming as many of the complexity requirements that need to be considered when LMICs are seeking to establish safe and sustainable radiotherapy services.

The RESEA Guide supports LMICs' efforts to appraising what is important in establishing sustainable and safe radiotherapy services. It helps LMICs to identify gap areas that need to be addressed prior to the establishment of a safe and sustainable radiotherapy service. The RESEA Guide is aimed to be a navigational and informative guide to help LMICs understand the radiotherapy service establishment process.

The RESEA Guide enables self-assessment against 37 important requirements that are organised under four readiness domains (Donkor et al. 2018; Donkor et al. 2020a, 2020b). Per the data integration process (refer to Chapter Three), the criteria for each requirement were

converted into readiness questions that called for response. The criteria in question formats are important because they are more conducive to identifying gaps and opportunities to the establishment of a safe and sustainable radiotherapy service.

Domain One: Identifying local COMMITMENT and support to improve radiotherapy service

Governments making the decision to mobilise and allocate the necessary resources to establish safe and sustainable radiotherapy service is considered the most important first step towards establishing safe and sustainable radiotherapy services. Political commitment and decision to establish safe and sustainable radiotherapy services in LMICs always have a clear starting point, which often include: a vision to expand access to radiotherapy services; local champions, such as civil society organisations and clinical leaders influencing political leaders; external pressure from international agencies/organisations, such as IAEA and UICC; and desire to address radiotherapy service demands of the population (Donkor et al. 2020a, 2020b).

To provide guidance for assessing LMICs' commitment, the RESEA Guide illustrates 12 key requirements that inspire the decision to establish safe and sustainable radiotherapy services, including: a safe, stable and supportive political environment; adequate and quality basic physical infrastructure service; opportunities for advocacy; policy coherence; integrated cancer control policy; public statements by political leaders; access to information; suitable funding model; commitment to universal health coverage; membership status with IAEA; legal and regulatory framework; and independent regulatory authority (Donkor et al. 2020a, 2020b) (refer to Table 7.2). Political leaders making the decision to establish safe and sustainable radiotherapy services help engage other stakeholders to develop the strategic radiotherapy service development and implementation plan.

Domain Two: Identifying COOPERATION between stakeholders to plan a radiotherapy service

Effectively cooperating with relevant international, national and local stakeholders helps with the strategic planning, commissioning and operationalisation of the new radiotherapy facility. The ARC Project's data confirmed that three requirements related to cooperation are considered essential, which include: strategic planning team; stakeholder involvement; and technical assistance plan (Donkor et al. 2020a, 2020b). The RESEA Guide outlines 15 questions to help determine LMICs' readiness to cooperate in the planning of the radiotherapy service.

Early in the process, a ministerial decision should be made about creating a strategic planning team, which may include: professionals with technical expertise, such as radiation oncologists; medical physicists; radiation therapists; hospital administrator; ministerial representatives (health, finance and education) and a legal member. To further explore the idea of establishing a safe and sustainable radiotherapy service, the strategic planning team ought to collaborate

and collectively conduct a comprehensive analysis to address the need, suitability and feasibility for establishing a radiotherapy service. All such data may be used to help engage relevant stakeholders and develop a conceptual design and strategic plan of the radiotherapy service to be implemented as well as specific financial plan (business case) and use of effective budgeting models (Donkor et al. 2020a, 2020b).

The RESEA Guide recognises that most LMICs will need international technical assistance from IAEA to successfully plan, organise and carry out a sequence of unfamiliar actions such as equipment commission plan. Similarly, the RESEA Guide acknowledges that the process of planning the establishment of a safe and sustainable radiotherapy service requires efforts from relevant stakeholders, such as radiation safety regulators (Donkor et al. 2020a, 2020b). To facilitate stakeholder involvement, planners ought to: conduct stakeholder mapping and analysis; identify stakeholders' critical roles and responsibilities; and ensure effective coordination of stakeholders' contributions. Early in the planning process, relevant stakeholders that ought to be engaged include but not limited: government; funding partners (banks); civil society organisations; professional bodies; individual professionals; and radiation regulatory authorities.

Domain Three: Identifying local CAPACITY to operationalise a radiotherapy service

When establishing a new radiotherapy service, it is important that there is an understanding of the requirements related to the capacity to implement, manage, organise, operationalise and maintain the radiotherapy centre (Donkor et al. 2020a, 2020b). The capacity requirements will certainly differ according to the LMIC, availability of resources, support and scope of the radiotherapy project. At a minimum, the availability of individuals such as: qualified architect; engineers (mechanical, civil, electrical); clinical professionals (radiation oncologist, medical physicist and radiation therapist); and cost consultant are essential to appropriately manage the implementation of the radiotherapy service. Consideration should be given to consulting external experts when radiotherapy expertise is unavailable locally (IAEA 2014).

As detailed in the RESEA Guide (refer to Table 7.2), essential requirements to determine capacity readiness include: creating a multidisciplinary implementation team; appointing a responsible project manager; availability of suitable land and addressing ownership related challenges; sourcing materials to construct the radiotherapy building; purchasing, delivering and setting up the radiotherapy equipment; negotiating for appropriate service contract; training and succession plan for developing radiotherapy workforce; instituting appropriate incentive systems; appointing a board to govern and manage the radiotherapy centre; and developing or adopting appropriate treatment guidelines, protocols and standard operating procedures (Donkor et al. 2020a, 2020b). It is worth noting that it could take 12-18 months to construct the radiotherapy building and six months to deliver and install the radiotherapy equipment. Also, it is

essential to recognise that the duration for training radiation oncologists, medical physicists and radiation therapists could last for 2-4 years (IAEA 2014).

In addition, access to other essential health services, such as laboratory and pathology ought to be considered early on in the planning and operationalisation process. The RESEA Guide recognises the importance of social support services, such as transport assistance programme. Civil society organisations with the capacity could collaborate the government to help with hostel accommodation for cancer patients and a family member who live some distance from the radiotherapy facility.

Domain Four: Recognising radiotherapy as a CATALYST to strengthen cancer care

It is important to recognise that newly developed and existing radiotherapy services are essential catalysts or window of opportunities to strengthen integrated cancer care. As shown in refer to Table 7.2, the essential catalyst requirements to support the provision of integrated cancer care include: encouraging cancer prevention and control reform; promoting coordinate cancer care; promoting patient and family-centred care; promoting a multidisciplinary approach to cancer care; and encouraging better outcomes through research (Donkor et al. 2020a, 2020b).

It is advantageous to be familiar with the criteria that support coordination and continuity of cancer care to ensure that cancer specialists and cancer patients communicate with each other. Information and communication technologies offer different advantages in terms of promoting the effective gathering and organisation of data to improve planning and delivering of cancer care. The information technologists should have the experience and knowledge to develop and implement safety and security procedures for managing cancer patients records and information (Donkor et al. 2020a, 2020b).

As previously mentioned, the ARC Project's end-point meta-inference confirmed that many steps overlap, and decisions may take place concurrently when establishing a safe and sustainable radiotherapy service. But, for ease of explanation, the RESEA Guide has been presented as a sequential set of self-assessment questions beginning with a stable, safe and supportive political environment of the LMIC.

7.5.1 Utilising the RESEA Guide

Embedded within the RESEA Guide are 120 structured questions that help LMICs at macro and meso levels to determine and create action plans to improve their readiness to establish safe and sustainable radiotherapy services (refer to Table 7.2). As described above, these questions ideally need to be answered to:

- identify local commitment and support to improve radiotherapy service;

- identify cooperation between stakeholders to plan a radiotherapy service;
- identify local capacity to operationalise a radiotherapy service; and
- recognise radiotherapy as a catalyst to strengthen cancer care.

It is recommended to progress by the following steps to assess the LMIC's readiness for the establishment of safe and sustainable radiotherapy service.

Step One: Create a multidisciplinary working group

The formation of a working group consisting of major stakeholders is useful to complete the RESEA Guide to facilitate the exchange of information and ideas during the establishment of the new radiotherapy service. Suggestions for the working group include experts, such as: ministry of health/finance representations; clinical leadership (radiation oncologist, medical physicist and radiation therapist); radiation safety regulator. Using a consensus process, the working group with the help of a skilled facilitator can create a safe environment where stakeholders are able to openly express their opinions, make necessary compromises and help the group arrive at decisions acceptable to all concerned. As a City Cancer Challenge initiative on improving cancer care services in LMICs has highlighted (Morton, Henshall & Aranda 2019), open dialogue, co-design and stakeholder engagement are key principles of effective utilisation of the Guide. Effective stakeholder engagement and community consultations create and sustain trust, cooperation and local ownership, which facilitate the implementation of the radiotherapy service (Brown et al. 2014; Donkor et al. 2018; Donkor et al. 2020b).

Step Two: Create a vision

Creating a clear vision is a major step in planning and conducting readiness assessment. Ideally, the radiotherapy service planners need to create a vision that stakeholders can identify and devote their attention and time. Having a vision for conducting the readiness assessment promotes the ability to reach a consensus on both challenges and possible solutions.

Step Three: Gather evidence for informed decision-making

To accurately assess LMICs' readiness to establish safe and sustainable radiotherapy services, it is essential to gather appropriate data to inform discussions and strategic planning. The available data can help identify where improvement may be required. Thus, data are gathered to prioritise problems and solutions.

Step Four: Answer the readiness questions

In operational terms, the completion of the RESEA Guide could take place in a one-day workshop or a series of workshops with the working group members, which could evaluate one domain of the RESEA Guide but scans the other domains to ensure that requirements that need

long-term planning such as finance, workforce, equipment purchase, quality assurance and commission are addressed concurrently.

The working group can proceed through the four domains of the RESEA Guide, answering each question to determine readiness and prioritise action plans. To avoid getting trapped in the details when assessing readiness, the working group ought to: read each of the questions; and consider the evidence provided to them to better inform and shape their decisions for each specific requirement for establishing a safe and sustainable radiotherapy service. It is recommended to discuss each question, reflect on their strengths, identify areas for improvement and develop possible solutions for each challenge. Assessing readiness is an ongoing process; not a one-off activity (Rollnick, Mason & Butler 2010). Hence, the RESEA Guide is designed to be used throughout the planning, implementation and maintenance of the radiotherapy service.

Table 7.2: The RESEA Guide for LMICs establishing safe and sustainable radiotherapy services

Domain 1 COMMITMENT				
Requirements		Questions	What is known (evidence)?	Next steps (actions)
1.1	Safe, stable and supportive political environment	- What is the LMIC's political and security situation? - Are there any international sanctions imposed on the LMIC? - Are there government structures and processes defined by laws to support financial accountability and transparency?		
1.2	Quality of basic infrastructure service	- What is the nature of the road and transport system that leads to the radiotherapy centre? - How consistent is water and electricity supply? - Is there evidence of infrastructure policy for the improvement of basic infrastructure services?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
1.3 Opportunities for advocacy	- Is there a vision that supports expanding access to radiotherapy services? - How widely is the vision to establish a radiotherapy service shared? - Is there a vision champion (e.g. civil society organisations or health professional) who is supportive of action to improve access to radiotherapy services? - Is the vision champion well equipped to lead engagement and advocacy efforts? - Are civil society organisations collectively working together? - Has the civil society organisation forged a link with international organisations?		
1.4 Policy coherence	Is there evidence of collaboration between government ministries and agencies to develop and implement cancer control plans?		
1.5 Cancer control policy	- Does the LMIC have a country-wide cancer control policy? - Is the cancer control policy costed? - Is there support to implement the cancer control policy?		
1.6 Public statements by political leaders	- Is there evidence of supportive statements by a political leader(s)/ministry of health to improve access to radiotherapy services? - Are there other things competing for the resources or time of political leaders?		
1.7 Access to information	- Is a population-based or hospital-based cancer registry data available in the LMIC? - Is there a plan to collaborate with the International Agency for Research on Cancer (IARC) Global Initiative for Cancer Registry Development to develop a cancer registry?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
1.8 Suitable funding model	- Is the required funding to establish the new radiotherapy available? - If not, is there evidence to support a business case for a radiotherapy service? - Is there evidence of collaboration between the ministry of health and ministry of finance in the process of developing a business case for a radiotherapy service?		
1.9 Commitment to universal health coverage	Is there evidence of efforts to address financial hardship at the point of radiotherapy service delivery?		
1.10 Membership status with the IAEA	- Is the LMIC a member of the IAEA? - If not, Is there evidence of the LMIC planning to establish membership with the IAEA?		
1.11 Legal and regulatory framework	- Does the LMIC have a legal and regulatory framework? - Is the regulatory framework adequately enforced?		
1.12 Independent regulatory authority	Is there evidence of an independent LMIC-level regulatory authority that is supportive of efforts to establish radiotherapy service as well as ensure compliance with international standards of radiation safety, security and protection?		

Domain 2**COOPERATION**

Requirements	Questions	What is known (evidence)?	Next steps (actions)
2.1 Strategic planning team	• Has the LMIC appointed individuals to constitute the strategic planning team? • Has a comprehensive need assessment been conducted? • If not, is there evidence of where data will be sourced for a need assessment? • Has the LMIC outlined how it will use the data from the comprehensive need assessment in the planning process? • Has the LMIC identified where it will find financial and human resources necessary to implement the radiotherapy service? • Has the strategic planning team provided a draft that outlines the strategic direction, priorities, goals and milestones as well as objectives to achieving the radiotherapy service development goal? • Has the final plan been reviewed, commented on and approved by the ministry responsible for health?		
2.2 Stakeholder involvement	• Is there evidence of a comprehensive list of all possible stakeholders? • Does the planning team have the necessary information about the stakeholders? • If not, does the planning team know where and how information about the stakeholders can be obtained?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
	- Does the planning team know how each stakeholder can contribute to influencing the radiotherapy project success? - Does the planning team know what constitutes satisfaction for each stakeholder? - Is there evidence of a strategy to effectively involve relevant stakeholders?		
2.3 Technical assistance plan	- Has the LMIC identified the kind of assistance and how much such assistance will be sourced from an international agency, organisations, volunteers or consultants? - Has the LMIC listed where it can find the assistance?		

Domain 3**CAPACITY**

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.1 Multidisciplinary implementation team	• Has the right implementation team that is responsible for the day-to-day management of the radiotherapy service implementation activities been assembled? • Are the members of the implementation team clear about their roles and responsibilities? • Has a system been set-up by the implementation team to communicate, monitor, evaluate and review the progress of the radiotherapy service implementation tasks?		
3.2 Responsible project manager	• Is there evidence of a project manager overseeing the implementation of the radiotherapy list of tasks? • Is the radiotherapy service implementation process guided by a realistic timeframe? • Have all the relevant stakeholders involved in implementing the radiotherapy service agreed on the timeframe?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.3 Availability of radiotherapy expertise	- Is the LMIC having access to adequate technical expertise locally to implement the list of tasks outlined in the radiotherapy service development action plan? - If not, has any arrangement been made to recruit external individuals with technical expertise to perform the radiotherapy service implementation tasks?		
3.4 Access to suitable land	- Is the land earmarked for the radiotherapy service legally registered? - If so, is there documentation of the land registration? - Is the land undergoing any form of hazard assessments? - If not, is there a plan for the land to undergo environmental and engineering assessments?		
3.5 Construction of the building	- Are there resources to support the construction of the radiotherapy building? - Are strategies implemented to ensure construction materials undergo appropriate quality assurance evaluations? - Is there a contingency plan to minimise or avoid construction delays? - Has the independent regulator been involved in the process of constructing the radiotherapy building?		
3.6 Equipment purchase, delivery and set-up:	- Has the LMIC purchased the right radiotherapy equipment, treatment planning system, quality assurance equipment, and other simulation and treatment accessories that are appropriate for the country? - Does the LMIC has the capabilities to install and commission the equipment? - If not, has the LMIC arranged to ensure timely installation, commissioning and licensing?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.7 Service contract	- Does the LMIC has enough information as well as the necessary knowledge to confidently understand and negotiate a radiotherapy service contract? - Has the contract been written with the involvement of a trained lawyer? - Is there an agreement on a planned maintenance strategy to ensure all necessary resources such as spare parts and engineers are available to reduce equipment downtime? - Is there an arrangement on support for training radiotherapy workforce and local engineers?		
3.8 Training for initial core staff	- Who are the core staff that will be involved in the delivery of the radiotherapy service? - How many initial core staff will be needed to effectively deliver safe and quality radiotherapy services? - What arrangement has been made to train and educate the core staff in an appropriate institution? - How much money is required for the training and education of the core staff? - Are there strategies in place for ensuring a sustainable radiotherapy workforce, with up-to-date knowledge and skills? - What are the regulatory mechanisms required to maintain quality of education, training and practice?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.9 Other supporting staff	- What other human resources (such as physiotherapists, dieticians and nurses) are available in the LMIC to support the delivery of quality radiotherapy services? - Do human resources have the required skills to support the delivery of radiotherapy services? - If not, is there a plan to train them?		
3.10 Staff succession plan	Is there evidence of a long-term plan to establish radiotherapy specific academic institution(s) to develop and allocate radiotherapy workforce?		
3.11 Incentive systems	- Has the LMIC established a succession plan that considers the training or appointment of radiotherapy staff? - Is there evidence of an incentive plan to attract and create an optimal mix of radiotherapy workforce?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.12 Governance and management structure	- Is there evidence of a radiotherapy governance-management structure for decision-making, administrative and executive functions? - Has a multi-stakeholder approach been used in choosing members of the radiotherapy service governance body to optimise performance? - If not, are efforts underway to appropriately define the composition of the governance and management board? - Are the roles and responsibilities of the radiotherapy service management board clearly defined? - Can the radiotherapy management board work as a team through collegial relationships that promote respect and trust? - Is there a plan to keep members of the radiotherapy management board up to date with the latest developments in radiotherapy?		
3.13 Treatment guidelines, protocols and standard operating procedures	- Has the radiotherapy management board reviewed current evidence and developed or adopted relevant clinical practice guidelines? - Has the radiotherapy management board considered its role in regularly updating the guidelines? - Has the radiotherapy service delivery process been defined? - Has a quality assurance policy been developed?		
3.14 Other essential health services	- Are health services, such as laboratory, pathology and imaging services readily available in the LMIC? - Have providers of different cancer care such as surgery been identified? - Are there any comparable radiotherapy centres in the LMIC that are exemplars?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
3.15 Social support services	• Is there assistance from the government to help introduce social services for cancer patients and their families? • Is there evidence of collaboration between the government and civil society organisations with the capacity to help with the provision of social services such as transport, meals and home help?		
3.16 Generate, compile, analyse and communicate health data	• Have enough funds been allocated to develop, implement and operate information management tools? • Have qualified information technologists been identified and prepared for positions of responsibility? • Do the information communication technology staff have the experience to develop and implement safety and security procedures for managing patients' records and information? • Has the LMIC considered its role in protecting patients' data?		

Domain 4**CATALYST**

Requirements	Questions	What is known (evidence)?	Next steps (actions)
4.1 Encourage cancer control reform	• Is there support and recognition from senior political and health leaders that establishing a radiotherapy service addresses an important gap in cancer control and improves equity in cancer treatment access? • Is there a plan to use the new radiotherapy service as a window of opportunity to promote and mobilise resources to develop a comprehensive cancer service and optimise all aspect of cancer control? • Is there a plan to use the new radiotherapy service to advocate and create awareness about the growing burden of cancer and the importance of integrated cancer control strategies for managing it?		
4.2 Promote coordinated care	• Are mechanisms such as nurse coordinator in place to take full advantage of the benefits of a coordinated cancer care? • Is there a relationship between service providers to facilitate effective communication and cancer patient referral to improve transition across specialists? • Are there information technology resources and policies that support coordination and continuity of care?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
4.3 Strengthen patient- and family-centred care	• Are cancer patients and their families engaged in meaningful interactions to develop an accurate treatment plan based on available medical information? • Are cancer patients given access to the relevant information they need to make informed decisions? • Is there evidence to develop or adapt educational materials to support self-management? • Is there evidence of collaboration between the radiotherapy centre and civil society organisations to promote awareness about the benefits of radiotherapy services?		
4.4 Promote a multidisciplinary approach to care	• Does the multidisciplinary oncology team (MDT) have the appropriate composition, with the right mix of specialist skills and experience to take responsibility of the cancer patient care planning? • Do the MDT members have a keen interest to communicate, manage and learn from others to effectively address patients' needs? • Is there a chairperson with strong leadership to promote mutual professional respect among members of the MDT? • Is clinical information adequately shared to help MDT members understand the health problem prior to the meeting? • Are MDT members committed to regular meetings? • There is a process for communicating treatment outcomes and recommendations to patients and their general practitioners?		

Requirements	Questions	What is known (evidence)?	Next steps (actions)
	Is there evidence of an auditing mechanism to review the MDT functionality such as communication among MDT members and patients, meeting attendance and outcomes?		
4.5 Encourage better outcomes through research	- Does the LMIC understand the value of oncology research? - Is there evidence of collaboration between the radiotherapy centre in the LMIC and different centres (international and/or regional) to improve oncology research? - If not, is there a plan to establish collaboration between the radiotherapy centre in the LMIC and different centres (international and/or regional) to improve oncology research? - Has the focus of the research collaboration clearly defined? - Have funds been allocated for research?		

Name of facilitator:

Date completed:

7.5.2 Next steps for the RESEA Guide

The ARC Project has produced the first version of the RESEA Guide to help determine LMICs readiness to establish safe and sustainable radiotherapy services. The next step is to pilot test the RESEA Guide in partnership with interested LMICs who are seeking to establish a new radiotherapy service. Such piloting should be aimed at learning from the experience of LMICs in implementing the RESEA in order to inform further refinements. During the pilot testing of the RESEA Guide, the number of participants will be expanded to include nurses, so that it is more representative.

The following avenues will be pursued to disseminate the RESEA Guide to relevant parties within LMICs who may be interested in using it and providing feedback:

- publishing it in an open access journal;
- posting the RESEA Guide on a website, ideally with the capacity to enable feedback;
- promoting access to the RESEA Guide through conferences, social media and email distribution; and
- sharing the electronic version of the RESEA Guide with leaders of IAEA-Programme of Action for Cancer Therapy.

7.6 Implementation support for the RESEA Guide

The section below outlines the supports required to ensure successful implementation of the RESEA Guide. These implementation supports include:

- provide leadership and stakeholder support by:
 - identifying and establishing communication with international agencies/organisations, such as IAEA, UICC, Radiating Hope and Asia-Pacific Radiation Oncology Special Interest Group of the Royal Australian and New Zealand College of Radiologists to create a supportive context for the RESEA Guide;
 - connecting and integrating the RESEA Guide's overarching goal into the IAEA-Programme of Action for Cancer Therapy policy and practice of strengthening integrated cancer care in LMICs;
 - building and encouraging an online-based community of champions to garner support for using the RESEA Guide to determine LMICs readiness to establish safe and sustainable radiotherapy services as well as determine and mobilise resources to facilitate the radiotherapy service establishment process;

- building upon the support and relationship with IAEA and/or UICC and create a web-based platform to allow clinical champions/leaders within LMICs to easily connect and access the RESEA Guide; and
- encouraging leaders to use feedback processes to share their success stories for using the RESEA Guide to improve the radiotherapy service establishment process.
- encourage planning teams to think through the assessment questions and data required to answer the ‘what, why and how?’ of the information being captured by the RESEA Guide;
- provide technical advice and consultancy in an effective and efficient manner, using both knowledge from the RESEA Guide and experience to achieve favourable establishment of safe and sustainable radiotherapy services in LMIC;
- local and international conferences provide opportunities for the researcher to share the RESEA Guide with clinical leaders, government officials, academics and civil society organisations and get responses from them;
- collaborate with international agencies/organisations to provide training and coaching to users of the RESEA Guide for them to acquire and use readiness assessment skills; and
- provide supportive evidence that:
 - highlight the positive outcomes from the RESEA Guide adoption; and
 - outline examples of LMICs who have used the RESEA Guide and illustrate how and why they have been successful.

7.7 Strengths and limitations of the ARC Project

The ARC Project has several strengths and limitations, as outlined below.

7.7.1 Strengths

Data were gathered by consulting widely and capturing the views and experiences of 10 local radiotherapy experts in nine LMICs, as well as seven international radiotherapy experts who have worked with several LMICs to strengthen radiotherapy services. The ARC Project has been a collaborative process that has led to the development of a low cost and simple RESEA Guide that could help policy-makers, planners and implementers to establish successful radiotherapy services in LMICs.

Rigorous data collection and analysis approaches were ensured for all studies within the ARC Project. The systematic review was conducted and reported in accordance with the Preferred

Reporting Items for Systematic Review and Meta-Analysis (PRISMA) Statement (Moher et al. 2009). Similarly, the semi-structured interviews and participant validation process were guided by the Consolidated criteria for Reporting Qualitative research (COREQ) (Tong, Sainsbury & Craig 2007). These reporting strategies ensured each study achieved a high standard of rigour and consistency.

7.7.2 Limitations

In addition to the limitations reported in each of the ARC Project study Chapters, the following limitations need to be highlighted. A critical challenge in recruiting global radiotherapy experts to the ARC Project is related to the accurately identifying clinicians email accounts and organisational firewalls. There were few active email accounts of the radiotherapy experts. Hence, only global radiotherapy experts who could be contacted were included in the ARC Project. This may have limited the opportunity of radiotherapy experts working in LMICs from contributing to the project.

Like all qualitative studies, the data is not generalisable. However, that limitation is balanced by the use of a participant validation process which sought participant's feedback, and the use of purposive and snowball sampling strategies to ensure appropriate representation of the global experts. As all of these global experts are busy clinicians, many (n=10) did not have the time to complete the participant validation process. As each participant was required to read and complete an extensive list of readiness requirements, this has the potential to increase the risk of participant fatigue.

Also, because almost half of the participants came from HICs, but with experience in establishing radiotherapy services in LMICs, their views may not reflect those who worked in LMICs.

Finally, participation in the ARC Project was voluntary. Consequently, no nurse was interviewed. Also, no medical physics experts who participated in the semi-structured interviews contributed to the participant validation process. As a result, the participants may not necessarily represent the broader cancer care professionals working in LMICs. Future engagement on the RESEA Guide with nurses and medical physicists is required.

7.8 Implications

The ARC Project has highlighted the importance of readiness assessment when establishing safe and sustainable radiotherapy services in LMICs. The section below presents the policy, research and practice implications of the ARC Project.

7.8.1 Implications for policy

Invest wisely in the development and allocation of radiotherapy workforce. The ARC Project has highlighted the importance of investing in the training and education of the radiotherapy workforce in LMICs. It is important to recognise the advantage of collaboration between academic health institutions and Ministries responsible for health, education and finance for ensuring that radiotherapy workforce receives appropriate, targeted and timely training. Building a competent and effective radiotherapy workforce is key to making the provision of quality and safe radiotherapy service a reality in LMICs. It is key to recognise that continuing professional development has an impact on ensuring knowledge and skill refinement of the radiotherapy workforce to deliver quality and safe radiotherapy service. Investing in innovative learning strategies such as integrated e-learning with elements from face-to-face learning, distance education and practical work is a critical mechanism to support the development of the radiotherapy workforce in LMICs. Importantly, LMICs should ensure that they engage IAEA through its technical cooperation programme to help build, strengthen and maintain radiotherapy human resources for the safe and quality delivery of radiotherapy services.

Develop advocacy and leadership skills for championing radiotherapy. A key finding of the ARC Project was the evidence of awareness and advocacy to influence political leaders to mobilise and allocate the necessary resources to establish safe and sustainable radiotherapy services. Civil society organisations and/or individuals building coalition is an essential strategy to effectively galvanising support to lobby political leaders. Civil society organisations or local champions strength to influence political leaders/governments to secure political commitment is driven by strong networking, leadership, access to local knowledge, credibility, legitimacy and trustworthiness. Developing skills for pitching radiotherapy service idea is well worth acquiring to influence senior political leaders to invest wisely in radiotherapy services. Identifying the right or opportune time to advocate for senior political leaders' commitment and creating a persuasive message by using compelling scientific evidence is crucial in convincing policy and decision-makers about the benefits of establishing safe and sustainable radiotherapy services in LMICs.

Ensure consistent radiotherapy financing via multi-sectoral partnerships. The ARC Project acknowledged the importance of long-term financial commitment to help establish and maintain the radiotherapy service. Developing multi-sectoral partnership is one of the strategies that is closely linked to raising long-term financing for safe and sustainable radiotherapy services. Multi-sectoral partnership works from a diversified funding source, ranging from public, philanthropic and/or private sector. It is essential to create a compelling business case and align the vision to establish a safe and sustainable radiotherapy service to funding partners' priorities. The LMIC should prioritise working with IAEA-Programme of Action for Cancer Therapy to assess its needs, capacity, mobilise the necessary resources and develop strategic documents, such as: bankable planning and funding documents; and country-wide cancer control plans.

Build integrated cancer control policies. Prioritising the development and implementation of integrated cancer control policies in LMICs is crucial to minimising fragmentation in cancer care and financing. A key finding of the ARC Project was that an integrated cancer control policy is often effective when it is costed and incorporates prevention, diagnosis, treatment and palliative care strategies. An integrated cancer control policy creates an enabling and authorising environment for continual improvement of cancer treatment and care services for people with cancer and their families. Regularly updating the integrated cancer control policy with new scientific evidence and priorities of the LMIC is crucial.

7.8.2 Implications for future research

Regular evaluation and monitoring of the RESEA Guide in radiotherapy initiatives in different contexts is required to enhance long-term learning and refinement of the RESEA Guide. This will enhance implementation effectiveness and better position the radiotherapy field to develop innovative solutions to meet future implementation challenges in a dynamic context. Innovative solutions to expand radiotherapy services in LMICs should be flexible, responsive to LMICs' realities and must reflect the views of relevant stakeholders while sharing responsibility for decision-making.

Understanding factors that significantly influence stakeholder involvement is equally important to ensure that initiatives to establish safe and sustainable radiotherapy services are well received and address issues that matter most to stakeholders. Conducting rigorous studies in radiotherapy service implementation in LMIC will generate strong evidence that will facilitate investment in initiatives to expand radiotherapy services in LMICs.

7.8.3 Implications for practice

It is important to note that LMICs establishing safe and sustainable radiotherapy services ideally need technical assistance from IAEA and other global radiotherapy expert volunteer organisations. Most LMICs require support to effectively negotiate with vendors to ensure effective contract management. LMICs developing a maintenance plan is crucial to ensure local engineers are trained and spare parts readily available when needed.

A key finding of the ARC Project was the evidence of the lack of reliable epidemiological data to inform the development of cancer care services in LMICs. Developing population and/or hospital-based cancer registries is an important first step in providing strong evidence, which can lead to making good decisions about the necessary resource mobilisation and allocation. International agencies and/or organisations working together with LMICs to build local capacity to design, develop, implement and sustain cancer registries is essential.

In practice, it takes time to decide, plan, operationalise and leverage off radiotherapy services in LMICs. Assessing LMICs' need and readiness to establish safe and sustainable radiotherapy

services by identifying areas of weakness, strengths and opportunities is critical. Informing the planning decisions related to the design and implementation of the radiotherapy service is a crucial practical component to avoid wasting scarce resources. It is important for funding partners and other relevant stakeholders to understand and accept the crucial role of readiness assessment prior to establishing safe and sustainable radiotherapy services in LMICs.

Lastly, a key finding of the ARC Project was good project management in planning, coordinating and monitoring of the establishment of safe and sustainable radiotherapy services in LMICs. The radiotherapy workforce, particularly radiation oncologists, radiation therapists and medical physicists will benefit greatly from training in communication, leadership and management of radiotherapy projects to improve efficiency and coordination of radiotherapy project activities in LMICs.

7.9 Conclusions

The ARC Project has identified a complex combination of facilitators and barriers that influence the establishment of safe and sustainable radiotherapy services in LMICs. These factors include: political leadership; awareness and advocacy; financial resources; basic physical infrastructure; epidemiological data and cancer control policy; radiotherapy workforce training and education; and radiation safety legislative and regulatory framework (Donkor et al. 2018; Donkor et al. 2020a, 2020b). These factors highlight the importance of developing a comprehensive understanding of the country-level readiness factors that need to be considered when establishing a safe and sustainable radiotherapy service in any LMIC.

The ARC Project has created the RESEA Guide to enable LMICs appraise their readiness to establish safe and sustainable radiotherapy services. Importantly, the RESEA Guide offers practical support for LMICs to better understand the barriers and select appropriate risk response strategies to ensure successful establishment of safe and sustainable radiotherapy services.

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Donkor, A., Lockett, T., Aranda, S., Phillips, J.L 2018, 'Barriers and facilitators to implementation of cancer treatment and palliative care strategies in low-and middle-income countries: systematic review', *International Journal of Public Health*, vol. 63, no. 9, pp. 1047–57

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Barriers and facilitators to implementation of cancer treatment and palliative care strategies in low- and middle-income countries: systematic review

Andrew Donkor^{1,2} · Tim Lockett¹ · Sanchia Aranda^{1,3} · Jane Phillips¹

Received: 22 February 2018 / Revised: 21 June 2018 / Accepted: 26 June 2018 / Published online: 5 July 2018
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Abstract

Objectives To appraise improvement strategies adopted by low- and middle-income countries to increase access to cancer treatments and palliative care; and identify the facilitators and barriers to implementation.

Methods A systematic review was conducted and reported in accordance with PRISMA statement. MEDLINE, CINAHL, and the Cochrane Library databases were searched. Bias was assessed using the Standards for Quality Improvement Reporting Excellence, and evidence graded using the Australian National Health and Medical Research Council system.

Results Of 3069 articles identified, 18 studies were included. These studies involved less than a tenth ($n = 12$, 8.6%) of all low- and middle-income countries. Most were case reports (58%), and the majority focused on palliative care ($n = 11$, 61%). Facilitators included: stakeholder engagement, financial support, supportive learning environment, and community networks. Barriers included: lack of human resources, financial constraints, and limited infrastructure.

Conclusions There is limited evidence on sustainable strategies for increasing access to cancer treatments and palliative care in low- and middle-income countries. Future strategies should be externally evaluated and be tailored to address service delivery; workforce; information; medical products, vaccines, and technologies; financing; and leadership and governance.

Keywords Neoplasms · Surgery · Radiotherapy · Chemotherapy · Palliative care · Low- and middle-income countries

Introduction

Many low- and middle-income countries (LMICs) are ravaged by significant socioeconomic and healthcare challenges, including a rapid escalation in non-communicable diseases (NCDs), particularly cancer (Meara et al.

2015). Between 1990 and 2013, the 70% increase in cancer mortality occurred in LMICs, with 196.3 million disability-adjusted life years lost (Global Burden of Disease Cancer Collaboration et al. 2015). Globally, cancer incidence is projected to increase to 22.2 million new cancer cases by 2030, and LMICs will bear the major burden (Bray et al. 2012).

To date, the focus has been on cancer prevention and screening strategies in LMICs (Hanson et al. 2015; Raesima et al. 2015). But to improve survival and quality of life, equitable access to cancer treatment and palliative care are imperative (Knaul et al. 2011). However, many LMICs lack: national policies, infrastructure, skilled workforce, financial resources, technology, and information system for quality cancer treatment and palliative care (Knaul et al. 2011; Ngwa and Ngoma 2016). Currently, 90% of cancer patients in low-income countries are unable to access quality surgical care (Meara et al. 2015; Sullivan et al. 2015) and a third of LMICs have no functional radiotherapy services (Abdel-Wahab et al. 2017), while a fifth of

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those that do have only one radiotherapy machine per five million or more population (Abdel-Wahab et al. 2017; Atun et al. 2015; Datta et al. 2014). In most LMICs, late-stage presentation is common and the only treatment option is palliative care (Knaul et al. 2011; World Health Organisation (WHO) 2007b). Yet, many LMICs are not able to provide the 52 cancer medicines and 22 pain and palliative care medicines on the WHO's List of Essential Medicines (Vanderpuye et al. 2017; Wirtz et al. 2017). Consequently, 80% of people living in LMICs have little or no access to pain relief (Knaul et al. 2017). Given these challenges, innovative, cost-effective, and applicable improvement strategies are urgently needed.

High-income countries (HICs) able to develop, implement, and sustain scale-up strategies have made progress in expanding access to cancer treatment and palliative care. Several systematic reviews focusing on access to cancer treatment and palliative care in HICs have documented: (1) facilitators such as drive for quality clinical outcomes, strong political commitment, continuity of care, financial resources, educational opportunities, and patient need for care; and (2) barriers such as lack of knowledge, lack of awareness and support, competing priorities, and pervasive misconceptions about treatment quality (Chamberlain et al. 2016; Lockett et al. 2013; Obeidat et al. 2011; Thompson et al. 2017).

Understanding barriers and facilitators across policy, healthcare organisation and community are essential to inform access strategy implementation (WHO 2002a). Few systematic reviews in this area have focused on LMICs, which continue to hamper strategy implementation required to optimise cancer treatment and palliative care efforts. Accordingly, the aims of this systematic review were to: appraise improvement strategies adopted by LMICs to increase access to cancer treatment and palliative care; and identify the facilitators and barriers to implementation.

Methods

A systematic review conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Moher et al. 2009).

Eligibility criteria

Included studies were: all conducted in countries categorised by the World Bank Group (2017) Classification as being 'low income', 'middle income', 'developing', 'less resourced' or 'limited resourced'; published in an English peer-reviewed journal since 1990; reporting empirical data

related to the impact of a strategy, intervention, or programme designed to improve access to cancer surgery, radiotherapy, cancer medicines, and/or palliative care. An 'access improvement strategy' was defined as any programme, plan, intervention, or policy implemented to ensure cancer surgery, radiotherapy, chemotherapy, other essential cancer medicines, and/or palliative care services which were more available, accessible, adequate, affordable, and appropriate. Studies focusing exclusively on cancer prevention or early detection were excluded.

Information sources and search strategy

Search terms were devised from relevant Cochrane Reviews (Dudley and Garner 2011; Kredt et al. 2013). A combination of Medical Subject Headings (MeSH) and keywords for LMICs, cancer, treatment modalities, and healthcare delivery were used. Table ESM 1 in the Online Resource shows the detailed search strategy.

Between 4th April and 6th May 2017, three electronic databases—MEDLINE (EBSCO), CINAHL (EBSCO), and the Cochrane Library, were searched for relevant articles. These were selected, as they provide indexing for extensive international journals and regularly updated with relevant resources covering health topics. Reference lists of relevant articles were hand-searched to identify additional articles. Articles were exported to, and managed in, EndNote X8 software.

Study selection

After the removal of duplicates, all titles and abstracts were screened against the eligibility criteria (AD). Ten per cent of the articles were screened by a second reviewer (TL), with 98.5% agreement being reached. Ineligible articles were removed. Full text of all potentially relevant articles was retrieved, and further eligibility and quality assessments were undertaken by AD alone, with discussions among the wider team as necessary.

Data items and collection process

Data were extracted into a standardised data collection form using Microsoft Excel 2016 (AD) guided by a modified Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) tool (Ogrinc et al. 2016).

Quality assessment

The quality of the studies was also assessed based on SQUIRE (AD). The Australian National Health and Medical Research Council-approved rating system was used to rank the level of evidence.

Synthesis

The multi-level WHO Innovative Care for Chronic Conditions (ICCC) framework was adopted as the analytical framework for this review (WHO 2002a). This framework details the essential building blocks for action at the: micro-levels (patient and family), meso-levels (healthcare organisation and community), and macro-levels (positive policy environment) for developing and re-designing healthcare systems globally (refer Fig. 1; WHO 2002a). The ICCC framework also integrates the six building blocks identified by the WHO as being necessary for strengthening health systems globally, namely service delivery; health workforce; information; medical products, vaccines, and technologies; financing; and leadership and governance (stewardship) (WHO 2007a).

Due to the range of designs and outcomes involved, a narrative synthesis using approaches described by Popay and et al. (2006) was adopted. Included studies were independently coded by two reviewers (AD and TL) to map strategies against the ICCC framework levels. Any discrepancies were resolved through discussion.

Results

The initial search identified 3063 articles, with another six identified during hand searching. After removal of duplicates and screening, 138 articles underwent a full-text review. Nineteen articles met inclusion criteria, with one study reported across two publications (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009; refer Fig. 2).

Study characteristics

Evidence on strategies for increasing access to cancer treatments and palliative care came from 12 different LMICs, mostly African nations. Table ESM 2 in the Online Resource shows the strategies in the included studies.

The majority of studies (61%, $n = 11$) focused on increasing palliative care access (Ali 2016; Banerjee 2009; Boit et al. 2014; Gafer and Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Paiva et al. 2012; Shamieh and Hui 2015; Tapsfield and Bates 2011; Wang et al. 2013), while a fifth (22%, $n = 4$) focused on strengthening radiotherapy services (Agrawal et al. 2011; Efstathiou et al. 2016; Einck et al. 2014; Galalae et al. 2015). A tenth (11%, $n = 2$) focused on improving integrative cancer care (Brown et al. 2017; Nwogu et al. 2016), and only one study focused on improving anti-cancer drug access (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009).

Fig. 1 Innovative care for chronic conditions framework adapted with permission granted by WHO (2002a)

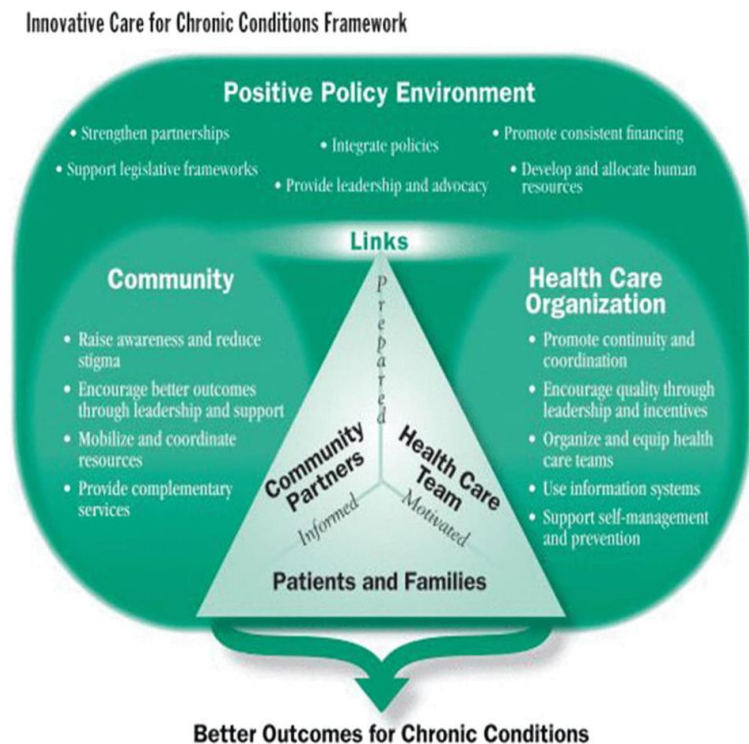
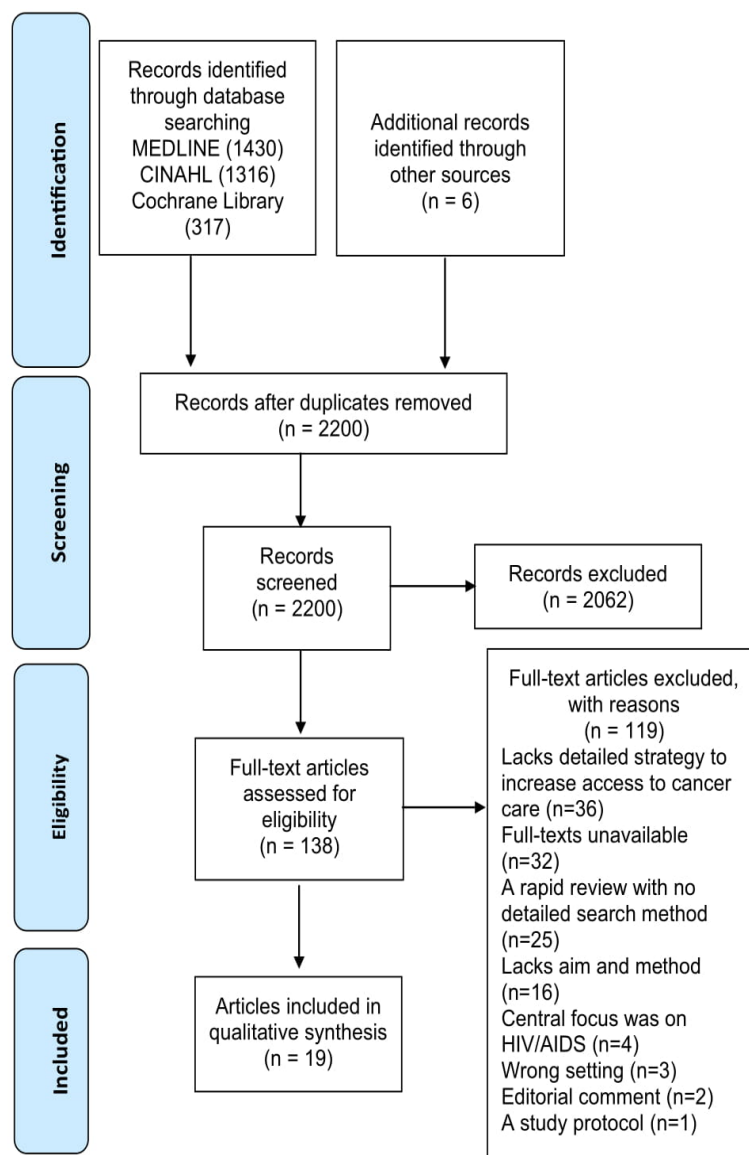


Fig. 2 Flow diagram illustrating study search and selection in the systematic review on barriers and facilitators to implementation of cancer treatment and palliative care strategies in low- and middle-income countries



Quality assessment

Apart from one (Wang et al. 2013) randomised controlled trial (RCT), with high cross-group contamination, the studies all generated low-level evidence predominately from case reports ($n = 11$, 61%; Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015; Krakauer et al. 2015; Nwogu et al. 2016; Shamieh and Hui 2015). Overall, the studies were of poor quality. None were underpinned by a conceptual framework or theory; two-thirds (67%, $n = 12$) did not evaluate the strategy (Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014;

Gafer and Elhaj 2014; Garcia-Gonzalez et al. 2015; Krakauer et al. 2015; Nwogu et al. 2016; Shamieh and Hui 2015; Tapsfield and Bates 2011); 44% ($n = 8$) did not describe the methods (Boit et al. 2014; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015; Krakauer et al. 2015; Shamieh and Hui 2015); and less than a third ($n = 5$) had secured ethics approval (Galalae et al. 2015; Herce et al. 2014; Paiva et al. 2012; Tapsfield and Bates 2011; Wang et al. 2013).

Positive policy environment facilitators and barriers

Seven main positive policy environment facilitators emerged as being crucial to the successful implementation of the access improvement strategies (refer Table 1). Stakeholder engagement (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015; Herce et al. 2014; Kanavos et al. 2009; Krakauer et al. 2015; Nwogu et al. 2016; Tapsfield and Bates 2011) and financial support (Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Gafer and Elhaj 2014; Garcia-Gonzalez et al. 2015; Herce et al. 2014; Kanavos et al. 2009; Nwogu et al. 2016; Tapsfield and Bates 2011) were identified as critical facilitators across all access improvement strategies implementation. Embedding a shared understanding of the project importance and the proposed action(s) and facilitating a sense of co-creation and ownership were the key primary focus of the stakeholder engagement strategies implemented across the projects. Through the co-creation of a cancer centre, there was an estimated 17% average annual increase in cancer patients accessing care which was observed between 2014 and 2016 (Nwogu et al. 2016).

Five key positive policy environment barriers that impeded the implementation of the planned access improvement strategies were identified. Across four studies, lack of human resources was the most critical barrier to the implementation of access improvement strategies (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014). Several studies acknowledged financial constraints and lack of political commitment as major barriers to implementation (Ali 2016; Nwogu et al. 2016). Collectively, these identified barriers contributed to: strategy implementation delays (Ali 2016; Gafer and Elhaj 2014), high health professionals workloads (Efstathiou et al. 2016; Einck et al. 2014), and patients experiencing long waiting times to be seen by health professionals (Brown et al. 2017; Nwogu et al. 2016).

Healthcare organisation facilitators and barriers

Of the eight healthcare organisation facilitators identified, creating a supportive learning environment was key to increasing integrated cancer care, radiotherapy, and/or palliative care access. Thirteen studies with varying levels of evidence reported creating a supportive learning environment for health professionals to develop specialist and generalist knowledge and skills (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017;

Gafer and Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh and Hui 2015; Tapsfield and Bates 2011). The RCT reported a significant increase in patients' knowledge of cancer pain and pain control by employing task-shifting strategy ($p < 0.05$; Wang et al. 2013). Few studies targeted financial hardship and treatment adherence by offering free access to essential cancer and palliative care medicines (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009; Lal et al. 2015). While a significant increase in survival could not be determined in a retrospective review of the outcome of the free drug donation strategy, a three-year survival rate of 66% was reported among 13,568 patients (Kanavos et al. 2009). Access improvement strategies tailored to local resources and conditions generated better acceptance of the changes (Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015).

Ten healthcare organisation barriers to access improvement strategies implementation were identified, with the majority related to radiotherapy access, such as limited physical infrastructure (Efstathiou et al. 2016; Einck et al. 2014), lack of radiotherapy equipment (Efstathiou et al. 2016; Einck et al. 2014), and radiotherapy equipment maintenance difficulties (Efstathiou et al. 2016). Untimely, delivery of appropriate radiotherapy doses was a major negative consequence. The most challenging aspect of chemotherapy access improvement strategies was: poor Internet connectivity, identifying and verifying eligible cancer patients, as well as maintaining communication between strategy providers and health professionals (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009). While a small number of studies suggested that prohibitive cancer treatment cost limited access for cancer patients and their families (Einck et al. 2014; Nwogu et al. 2016), no economic evidence estimating the direct and indirect treatment costs was provided.

Community facilitators and barriers

Two community facilitators that supported the successful implementation of integrative cancer care and palliative care access improvement strategies were identified (Boit et al. 2014; Herce et al. 2014; Nwogu et al. 2016). Across two studies, community networks were important providers of complementary services, such as socioeconomic supports (Boit et al. 2014; Herce et al. 2014). A critical facilitator was mobilising and coordinating community resources. One study acknowledged that establishing a non-governmental organisation (NGOs) offered unique opportunities to mobilised funds and coordinated with other community institutions to foster greater community buy-in of improvement strategies (Nwogu et al. 2016).

Table 1 Summary of the facilitators and barriers to implementation of cancer treatment and palliative care strategies in low- and middle-income countries, 1990–2017

ICCC levels	Facilitators	Barriers
Positive policy environment	Prepared health professionals (Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Gafer and Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh and Hui 2015; Tapsfield and Bates 2011)	Lack of human resources (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014)
	Financial support (Agrawal et al. 2011; Ali 2016; Boit et al. 2014; Brown et al. 2017; Efstathiou et al. 2016; Gafer and Elhaj 2014; Garcia-Gonzalez et al. 2015; Herce et al. 2014; Kanavos et al. 2009; Nwogu et al. 2016; Tapsfield and Bates 2011)	Financial constraints (Ali 2016; Nwogu et al. 2016)
	Political commitment (Agrawal et al. 2011; Ali 2016; Brown et al. 2017; Efstathiou et al. 2016; Herce et al. 2014; Krakauer et al. 2015)	Limited political commitment (Ali 2016; Nwogu et al. 2016)
	Stakeholder engagement (Brown et al. 2017; Nwogu et al. 2016; Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015; Herce et al. 2014; Kanavos et al. 2009; Krakauer et al. 2015; Tapsfield and Bates 2011)	Restrictive pharmacovigilance laws and regulations (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009)
	Positive relationships with international organisations (Ali 2016; Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014; Galalae et al. 2015; Krakauer et al. 2015; Nwogu et al. 2016)	Drug importation process challenges (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009)
	Committed champions (Ali 2016; Banerjee 2009; Boit et al. 2014; Gafer and Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Nwogu et al. 2016)	
	Strategy aligned with national policy (Efstathiou et al. 2016)	
Healthcare Organisation	Supportive learning environment (Agrawal et al. 2011; Ali 2016; Banerjee 2009; Boit et al. 2014; Brown et al. 2017; Gafer and Elhaj 2014; Herce et al. 2014; Krakauer et al. 2015; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh and Hui 2015; Tapsfield and Bates 2011)	Limited physical infrastructure (Banerjee 2009; Efstathiou et al. 2016; Einck et al. 2014; Gafer and Elhaj 2014)
	Recognition of patients' needs (Banerjee 2009; Brown et al. 2017; Gafer and Elhaj 2014; Garcia-Gonzalez et al. 2015; Herce et al. 2014; Kanavos et al. 2009; Lal et al. 2015; Nwogu et al. 2016; Paiva et al. 2012; Shamieh and Hui 2015; Wang et al. 2013)	Prohibitive treatment costs (Einck et al. 2014; Nwogu et al. 2016)
	Patient symptom management education (Banerjee 2009; Gafer and Elhaj 2014; Herce et al. 2014; Lal et al. 2015; Paiva et al. 2012; Shamieh and Hui 2015; Wang et al. 2013)	Lack of WHO essential pain and palliative care medicines (Gafer and Elhaj 2014)
	Strategy coordinator (Herce et al. 2014; Shamieh and Hui 2015; Tapsfield and Bates 2011)	Fragmented health system (Efstathiou et al. 2016)
	Adherence to evidence-based practice (Einck et al. 2014; Galalae et al. 2015)	Irregular meeting attendance (Agrawal et al. 2011; Brown et al. 2017)
	Strategy tailored to local resources and conditions (Einck et al. 2014; Galalae et al. 2015; Garcia-Gonzalez et al. 2015; Kanavos et al. 2009)	Limited or lack of radiotherapy equipment (Brown et al. 2017; Efstathiou et al. 2016; Einck et al. 2014; Nwogu et al. 2016)
	Information management system (Brown et al. 2017; Nwogu et al. 2016)	Poor Internet connectivity (Agrawal et al. 2011; Garcia-Gonzalez et al. 2015; Kanavos et al. 2009)
	Clearly defined strategy objectives (Agrawal et al. 2011; Brown et al. 2017; Galalae et al. 2015)	Radiotherapy equipment maintenance difficulties (Efstathiou et al. 2016)
		Periodic radiotherapy equipment breakdown (Efstathiou et al. 2016)
		Unstable electricity supply (Efstathiou et al. 2016)

Table 1 (continued)

ICCC levels	Facilitators	Barriers
Community	Strong community networks (Boit et al. 2014; Herce et al. 2014)	Culturally related beliefs, attitudes, and practices towards cancer and treatment modalities (Efsthathiou et al. 2016; Gafer and Elhaj 2014)
	Mobilisation and coordination of resources (Nwogu et al. 2016)	

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Culturally related beliefs, attitudes, and practices towards cancer and treatment modalities were the only community-level barrier identified which adversely impacted on communities or individuals' non-acceptance of the radiotherapy and palliative care access improvement strategies on offer (Efsthathiou et al. 2016; Gafer and Elhaj 2014).

Discussion

Unfortunately, there is no high-level evidence to recommend any particular strategy to increase access to cancer treatments or palliative care in LMICs. Most strategies have focused on increasing palliative care, and none on increasing access to surgical care, the mainstay of curative cancer care (Sullivan et al. 2015).

No strategies to date have been robustly evaluated or have included a health economic evaluation. None have made use of an implementation framework. However, despite limitations in the quality of the studies, the literature yields valuable insights of relevance to policy-makers, financiers, and researchers.

The included studies revealed numerous facilitators and barriers affecting the successful implementation of access improvement strategies at all three levels of the ICCC framework. These facilitators and barriers were complex and overlapping, concerned with: stakeholder engagement, financial support, supportive learning environment, strong community networks, lack of human resources, financial constraints, and limited infrastructure. These results confirm the complexity of implementing healthcare change, which requires an understanding of: processes of implementation; factors affecting implementation; the introduction of solutions, scale-up, and longer-term sustainability (Nilsen 2015; Peters et al. 2013).

Financing, partnership, legislative frameworks, policy integration, leadership and advocacy, development and allocation of human resources are key requirements of a positive policy environment (WHO 2002a). This review has highlighted the importance of acquiring the necessary financial support before embarking on any access improvement strategy. Financing of access improvement strategies determines who provides funds and who

exercises influence over the funds. International donors increasing their financing priority have been the key driving force for strengthening palliative care services in LMICs (Ali 2016; Boit et al. 2014; Gafer and Elhaj 2014; Herce et al. 2014; Tapsfield and Bates 2011), while locally based NGOs ability to established international ties is central to mobilising international funds for other cancer treatment initiatives (Nwogu et al. 2016). Donor funding approach for a specific purpose restricts strategy scope and limits the sponsors' ability to address unique local needs. This mismatch contributes to poor strategy acceptance at the local level.

The private sector's financial participation in the health sector in most LMICs has contributed significantly to the availability of radiotherapy (Efsthathiou et al. 2016), chemotherapy (Garcia-Gonzalez et al. 2015; Kanavos et al. 2009), and integrated cancer care (Nwogu et al. 2016). However, private sector financing approach in LMICs exposes patients without private health insurance and their families, who make up most of these populations, to extreme financial hardships, making it impossible for them to pay or adhere to care. As universal health coverage is yet to be fully realised in most LMICs (WHO and World Bank 2015), medical expenses related to cancer treatments continue to serve as a barrier to the successful improvement strategies implementation (Einck et al. 2014; Nwogu et al. 2016). There is an urgent need to institutionalise an appropriate financing system at the national level that offers the right financial incentives for providers and protects cancer patients from financial hardships (WHO 2007a).

Policies at the international, national, and regional levels are major issues in the successful implementation of access improvement strategies. This review identified a paucity of evidence about policy development and implementation to improve access to cancer treatments and palliative care. Recently, WHO (2002a, b) has assumed a more central position in providing supports for policy development process in most LMICs, which is crucial to driving in-country reform. A cancer policy framework helps guide critical decisions and systematic course of actions by governments and other stakeholders, both of which are essential to improving cancer control (Adshead and Thorpe 2008). In LMICs, there remains a significant need for:

credible policy agenda setting, realistic policy formulation, timely policy implementation, and periodic policy monitoring and evaluation using a theoretical framework (Exworthy 2008). Successful design and implementation of LMIC cancer control policies require high-quality health services research evidence, long-term commitment of resources, institutional capacity to enhance sustainability and reach of the policy, and co-designed approaches. While most of the cancer control policies developed in HICs offer useful starting points, LMIC policy-makers and supporting partners should consider the context, and power to obtain a full understanding of local policy process (Exworthy 2008).

Our findings are consistent with other literature on the need to gain commitment and buy-in from key stakeholders, especially those in positions of authority (Ramasmay and Gouillart 2010). Meaningful engagement of key stakeholders plays an essential role in achieving commitment at the political and community levels. Participatory and co-design-driven approach to implementation will assist in structuring health services to deliver effective, safe, and quality cancer treatments and palliative care. Participatory approach offers stakeholders a more active and significant role in: defining their priorities, diagnosing their challenges, securing funds, and implementing appropriate solutions for service improvement (Bate and Robert 2006).

The ICCC framework employs a population health approach including: promoting continuity and coordination, encouraging quality through leadership and incentives, organising and equipping healthcare teams, using information systems, and supporting self-management and prevention (WHO 2002a). The performance of the health workforce drives health system improvement strategies and determines how care is delivered. Developing and strengthening a country-based and country-led health workforce education initiative with appropriate international support is essential (Chen et al. 2004) if a responsive, fair, and efficient health outcome is to be realised. A country-based educational strategy helps reduce the outward migration of skilled health professionals from LMICs to HICs. An essential step towards achieving universal access to quality cancer treatments and palliative care is shifting human resource responsibilities and providing generalist doctors, nurses, allied health professionals, clinical pharmacists and community health workers with the necessary training, assessment tools, and essential medicines to deliver appropriate hospital and home-based care (Knaul et al. 2017; Knaul et al. 2011).

Implementation was largely affected by essential equipment challenges, particularly radiotherapy. Essential medical equipment, such as linear accelerators and high-dose-rate brachytherapy, is of paramount importance in

cancer treatments and palliative care. Access to essential medical equipment provides the required assurance of quality, safety, efficacy, cost-effective, and scientific care delivery (WHO 2007a). However, most LMICs: lack essential radiotherapy equipment, are faced with periodic radiotherapy equipment breakdowns, or have poor radiotherapy equipment maintenance culture. Given that radiotherapy equipment is expensive to install, it is imperative to develop and implement specific preventive and corrective maintenance schedules, procedures, and tasks to reduce unnecessary operational interruptions due to breakdowns. These challenges are part of a broader medical equipment problem in most LMICs. Hence, to improve access to essential medical equipment, there is a need to develop simple, quality, and affordable medical technologies. By designing and engineering tools, and techniques less than 500 nm in size, emerging field of nanotechnology offers significant opportunity in overcoming different barriers to cancer treatments (Cuenca et al. 2006). Such technologies can help reduce the size, weight, shielding, and shipping costs of medical equipment. Moreover, the technological advances can lead to a reduction in power consumption necessary for operating the equipment, and limited heat production. There should be greater emphasis on developing solar-powered equipment with high-quality insulation to limit the dependence on national power grid (Atun et al. 2015).

The ICCC framework assigns significant emphasis to the community, acknowledging both the individuals living in a place and the place itself (WHO 2002a). Informed and prepared community resources help to promote awareness and reduce stigma, provide leadership and support, and deliver complementary services to ensure better outcomes for chronic care conditions (WHO 2002a). Recognising that community agencies, organisations, institutions, opinion leaders, and concern citizens are major stakeholders in strengthening cancer treatments and palliative care delivery will require promoting acceptance and understanding of the notion of community involvement in health and development (Kahssay and Oakley 1999). The community development literature may prove useful in designing and implementing access improvement strategies. By definition, community development contributes to resource mobilisation, local empowerment, capacity development, and growth of political action through a network of relationships to help include the perspective and experience of grassroots (Helling et al. 2005).

Identified gaps

Investing and expanding surgical and radiotherapy capacity ought to be an important priority for all LMICs. Well-established knowledge of the minimum standards for

quality cancer surgery and radiotherapy already exist and include: establishing or adopting national accreditation systems, scaling up surgical and radiotherapy workforce, providing competency licence, and aligning surgical and radiotherapy access with universal health coverage (Atun et al. 2015; Meara et al. 2015; Sullivan et al. 2015).

Another gap relates to the lack of incentives and rewards available for health professionals in LMICs. Incentives and reward systems should be created for motivating health professionals. Both financial and non-financial incentives are essential to encourage health professionals to effectively perform, and engage in innovative clinical practice (WHO 2002a).

While there is an urgent need to increase the access to best evidence-based cancer care for people living in LMICs, this review highlights the importance of access to: universal health insurance, so that more people who need cancer care can afford to access the care they need; and essential cancer and palliative care medications, as per the WHO lists.

Future directions

There are opportunities to draw valuable lessons from the experience in developing and implementing HIV/AIDS strategies in LMICs, as well as cancer treatment and palliative care strategies in HICs. Key among these lessons are: global mobilisation and investment funds, engagement of pharmaceutical companies, development of simply health technologies, strengthening health workforce capacity, development of a supportive national policy framework, connecting health system with community resources, and community participatory in strategy development (Khumalo-Sakutukwa et al. 2008; Knaul et al. 2011; Muthee et al. 2018; Narayan et al. 2011). Recognising the importance of national policies in cancer control; dedicated financial budgets supporting cancer control; high level of advocacy and community involvement in strategy design; strong political support and acceptability of cancer control strategies; progress in cutting-edge technological advancements; and promoting high-quality cancer research and evidence-based treatment are critical to taking cancer care in LMICs to the next stage of their development (Knaul et al. 2011; Obeidat et al. 2011; Thompson et al. 2017).

Applying existing implementation research theories to future strategy designs will assist in strengthening the work undertaken to improve access to cancer treatments and palliative care in LMICs. Further research assessing LMICs' readiness to develop access improvement strategies as an essential precursor to an effective adoption is an important next step. A readiness assessment provides

strategy implementers with a preliminary understanding of the barriers and facilitators they are likely to encounter when implementing improvement strategies (Helfrich et al. 2009). To help prioritise actions and mitigate implementation barriers, increased focus on readiness is needed so that evidence base for LMICs capacity, preparedness, commitment, and willingness to support cancer treatment and palliative care strategy implementation, sustainability, and scale-up is available to assist policy-makers. Such focus is of particularly importance to expanding access to cancer treatment and palliative care in LMICs.

Strengths and limitations

The systematic search of articles and application of an internationally recognised framework are strengths of this review. While this review distilled various facilitators and barriers to the successful implementation from the studies, these were not systematically or explicitly investigated using primary research techniques. The results should be interpreted with caution because the studies included were low-level evidence, at the descriptive level except for one randomised control trial (Wang et al. 2013). None of the studies referenced the ICCC framework, which may not be an ideal 'fit' for some countries' health systems.

Conclusion

While modest progress has been made to increase access to cancer treatments and palliative care in LMICs, some major gaps still exist. In taking this work forward, LMICs are advised to adopt internationally recognised frameworks, such as the ICCC or the WHO's action framework intended to strengthen health systems to improve health outcomes to assist leaders to assess local population needs and integrate initiatives systematically, engage with the appropriate stakeholders, and secure the necessary financial support. It is essential to include an evaluation plan and budget during the development of the access improvement strategy. Needs assessment and design evaluation should be undertaken by an independent evaluator to ensure that a reliable blind outcome-based analysis is generated.

Authors' contributions All the authors contributed to the study design, manuscript development, editing, and completion of the manuscript. The article search and management were performed by AD. Article screening was completed by AD, and TL independently screened 10% of the articles. Quality assessment and study description were performed by AD. Coding of studies to the ICCC framework was performed by AD and TL. Data reduction was performed by AD and consensus discussions and finalising with JP, TL, and SA. Table design was completed by AD, JP, and TL.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article is based on a secondary analysis of the existing literature and does not contain any studies with human participants or animals performed by any of the authors. Good scientific standards have been followed according to the PRISMA statement.

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Appendix D: Search Strategy for Systematic Review

Database 1: MEDLINE (EBSCO) Search Strategy

Search ID	Search Term	Hits
S1	(MH "Afghanistan") OR (MH "Benin") OR (MH "Burkina Faso") OR (MH "Burundi") OR (MH "Central African Republic") OR (MH "Chad") OR (MH "Comoros") OR (MH "Democratic Republic of the Congo") OR (MH "Eritrea") OR (MH "Ethiopia") OR (MH "Gambia") OR (MH "Guinea") OR (MH "Guinea-Bissau") OR (MH "Democratic People's Republic of Korea") OR (MH "Liberia") OR (MH "Madagascar") OR (MH "Malawi") OR (MH "Mali") OR (MH "Mozambique") OR (MH "Nepal") OR (MH "Niger") OR (MH "Rwanda") OR (MH "Senegal") OR (MH "Sierra Leone") OR (MH "Somalia") OR (MH "South Sudan") OR (MH "Tanzania") OR (MH "Togo") OR (MH "Uganda") OR (MH "Zimbabwe") OR (MH "Armenia") OR (MH "Bangladesh") OR (MH "Bhutan") OR (MH "Bolivia") OR (MH "Cape Verde") OR (MH "Cambodia") OR (MH "Cameroon") OR (MH "Congo") OR (MH "Cote d'Ivoire") OR (MH "Djibouti") OR (MH "Egypt") OR (MH "El Salvador") OR (MH "Ghana") OR (MH "Guatemala") OR (MH "Honduras") OR (MH "India") OR (MH "Indonesia") OR (MH "Kenya") OR (MH "Kosovo") OR (MH "Kyrgyzstan") OR (MH "Lesotho") OR (MH "Mauritania") OR (MH "Micronesia") OR (MH "Moldova") OR (MH "Mongolia") OR (MH "Morocco") OR (MH "Myanmar") OR (MH "Nicaragua") OR (MH "Nigeria") OR (MH "Pakistan") OR (MH "Papua New Guinea") OR (MH "Philippines") OR (MH "Samoa") OR (MH "Sri Lanka") OR (MH "Sudan") OR (MH "Swaziland") OR (MH "Syria") OR (MH "Tajikistan") OR (MH "Timor-Leste") OR (MH "Tonga") OR (MH "Tunisia") OR (MH "Ukraine") OR (MH "Uzbekistan") OR (MH "Vanuatu") OR (MH "Vietnam") OR (MH "Yemen") OR (MH "Zambia") OR (MH "Albania") OR (MH "Algeria") OR (MH "American Samoa") OR (MH "Angola") OR (MH "Argentina") OR (MH "Azerbaijan") OR (MH "Republic of Belarus") OR (MH "Belize") OR (MH "Bosnia and Herzegovina") OR (MH "Botswana") OR (MH "Brazil") OR (MH "Bulgaria") OR (MH "Colombia") OR (MH "China") OR (MH "Costa Rica") OR (MH "Cuba") OR (MH "Dominica") OR (MH "Dominican Republic") OR (MH "Equatorial Guinea") OR (MH "Ecuador") OR (MH "Fiji") OR (MH "Gabon") OR (MH "Georgia") OR (MH "Grenada") OR (MH "Iran") OR (MH "Guyana") OR (MH "Iraq") OR (MH "Jamaica") OR (MH "Jordan") OR (MH "Kazakhstan") OR (MH "Lebanon") OR (MH "Libya") OR (MH "Macedonia (Republic)") OR (MH "Macedonia (Republic)") OR (MH "Malaysia") OR (MH "Mauritius") OR (MH "Mexico") OR (MH "Montenegro") OR (MH "Namibia") OR (MH "Palau") OR (MH "Panama") OR (MH "Paraguay") OR (MH "Peru") OR (MH "Romania") OR (MH "Russia") OR (MH "Serbia") OR (MH "South Africa") OR (MH "Saint Lucia") OR (MH "Saint Vincent and the Grenadines") OR (MH "Suriname") OR (MH "Thailand") OR (MH "Turkey") OR (MH "Turkmenistan") OR (MH "Venezuela")	792,892
S2	(MH "Developing Countries")	67,876
S3	(MH "Asia, Southeastern+") OR (MH "Asia, Central+") OR (MH "Asia, Northern+") OR (MH "Asia, Western+") OR (MH "Africa+") OR (MH "Central America+") OR (MH "South America+")	696,824

S4	TI ("Afghanistan" OR "Benin" OR "Burkina Faso" OR "Burundi" OR "Central African Republic" OR "Chad" OR "Comoros" OR "Democratic Republic of the Congo" OR "Eritrea" OR "Ethiopia" OR "Gambia" OR "Guinea" OR "Guinea-Bissau" OR "Democratic People's Republic of Korea" OR "Liberia" OR "Madagascar" OR "Malawi" OR "Mali" OR "Mozambique" OR "Nepal" OR "Niger" OR "Rwanda" OR "Senegal" OR "Sierra Leone" OR "Somalia" OR "South Sudan" OR "Tanzania" OR "Togo" OR "Uganda" OR "Zimbabwe" OR "Armenia" OR "Bangladesh" OR "Bhutan" OR "Bolivia" OR "Cape Verde" OR "Cambodia" OR "Cameroon" OR "Congo" OR "Cote d'Ivoire" OR "Djibouti" OR "Egypt" OR "El Salvador" OR "Ghana" OR "Guatemala" OR "Honduras" OR "India" OR "Indonesia" OR "Kenya" OR "Kosovo" OR "Kyrgyzstan" OR "Lesotho" OR "Mauritania" OR "Micronesia" OR "Moldova" OR "Mongolia" OR "Morocco" OR "Myanmar" OR "Nicaragua" OR "Nigeria" OR "Pakistan" OR "Papua New Guinea" OR "Philippines" OR "Samoa" OR "Sri Lanka" OR "Sudan" OR "Swaziland" OR "Syria" OR "Tajikistan" OR "Timor-Leste" OR "Tonga" OR "Tunisia" OR "Ukraine" OR "Uzbekistan" OR "Vanuatu" OR "Vietnam" OR "Yemen" OR "Zambia" OR "Albania" OR "Algeria" OR "American Samoa" OR "Angola" OR "Argentina" OR "Azerbaijan" OR "Republic of Belarus" OR "Belize" OR "Bosnia and Herzegovina" OR "Botswana" OR "Brazil" OR "Bulgaria" OR "Colombia" OR "China" OR "Costa Rica" OR "Cuba" OR "Dominica" OR "Dominican Republic" OR "Equatorial Guinea" OR "Ecuador" OR "Fiji" OR "Gabon" OR "Georgia" OR "Grenada" OR "Iran" OR "Guyana" OR "Iraq" OR "Jamaica" OR "Jordan" OR "Kazakhstan" OR "Lebanon" OR "Libya" OR "Macedonia (Republic)" OR "Macedonia (Republic)" OR "Malaysia" OR "Mauritius" OR "Mexico" OR "Montenegro" OR "Namibia" OR "Palau" OR "Panama" OR "Paraguay" OR "Peru" OR "Romania" OR "Russia" OR "Serbia" OR "South Africa" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR "Suriname" OR "Thailand" OR "Turkey" OR "Turkmenistan" OR "Venezuela")	445,700
S5	TI "third world countr*" OR AB "third world countr*" OR TI "less-developed countr*" OR AB "less-developed countr*" OR TI "under developed countr*" OR AB "under developed countr*" OR TI "underdeveloped countr*" OR AB "underdeveloped countr*" OR TI "developing nation*" OR AB "developing nation*" OR TI "less developed nation*" OR "less developed nation"	5,044
S6	TI "third world nation*" OR AB "third world nation*" OR TI "underdeveloped nation*" OR AB "underdeveloped nation*" OR TI "developing countr*" OR AB "developing countr*" OR TI "low income countr*" OR AB "low income countr*" OR TI "middle income countr*" OR AB "middle income countr*" OR TI "middle income nation*" OR AB "middle income nation"	58,527
S7	TI ("low and middle income") OR AB ("low and middle income") OR TI "resource limited countr*" OR AB resource limited countr* OR TI "resource limited set*" OR AB "resource limited set*" OR TI "Imic*" OR AB "Imic"	2,241
S8	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7	12,168
S9	(MH "Seychelles") OR (MH "Bahrain") OR (MH "Israel") OR (MH "Kuwait") OR (MH "Malta") OR (MH "Oman") OR (MH "Qatar") OR (MH "Saudi Arabia") OR (MH "United Arab Emirates") OR (MH "Japan") OR (MH "Korea") OR (MH "Singapore") OR (MH "New Zealand") OR (MH "Australia") OR (MH "Taiwan") OR (MH "France") OR (MH "Germany") OR (MH "Gibraltar") OR (MH "United Kingdom") OR (MH "Greece") OR (MH "Ireland") OR (MH "Italy") OR (MH "Andorra") OR (MH "Austria") OR (MH "Belgium") OR (MH "Portugal") OR (MH "San Marino") OR (MH "Netherlands") OR (MH "Monaco") OR (MH "Luxembourg") OR (MH "Liechtenstein") OR (MH "Spain") OR (MH "Switzerland")	992,671
S10	S8 NOT S9	1,023,176
S11	(MM "Neoplasms+")	2,539,783
S12	AB "cancer*" OR TI "cancer*" OR AB "tumo*" OR TI "tumo*" OR AB "malignan*" OR TI "malignan"	2,492,644

S13	S11 OR S12	3,390,242
S14	(MH "Surgical Oncology") OR (MH "General Surgery")	36,667
S15	AB "surger*" OR TI "surger*" OR AB "oncolog*" OR TI "oncolog"	1,040,148
S16	S14 OR S15	1,064,344
S17	(MH "Radiotherapy+") OR (MH "Radiation Oncology")	162,023
S18	TI "Radiotherap*" OR AB "Radiotherap*" OR TI "Brachytherap*" OR AB "Brachytherap*" OR TI "Radiat*" OR AB "Radiat*" OR TI ("external beam radiotherapy") OR AB ("external beam radiotherapy")	154,640
S19	S17 OR S18	251,743
S20	(MH "Drug Therapy") OR (MH "Chemotherapy, Adjuvant") OR (MH "Antineoplastic Combined Chemotherapy Protocols") OR (MH "Drug Therapy, Combination") OR (MH "Antineoplastic Combined Chemotherapy Protocols") OR (MH "Induction Chemotherapy") OR (MH "Maintenance Chemotherapy") OR (MH "Pharmaceutical Services+")	379,423
S21	TI "chemotherap*" OR AB "chemotherap*" OR TI "drug*" OR AB "drug*" OR AB "pharmac*" OR TI "pharmac*" OR AB "anticancer*" OR TI "anticancer*" OR AB "anti-cancer*" OR TI "anti-cancer*" OR AB "anti-tumo*" OR TI "anti-tumo"	2,062,060
S22	S20 OR S21	2,251,254
S23	(MH "Immunotherapy")OR (MH "Molecular Targeted Therapy")	51,596
S24	TI "Immunotherap*" OR AB "Immunotherap*" OR TI "Hormon*" OR AB "Hormon"	545,345
S25	S23 OR S24	578,072
S26	(MM "Palliative Care") OR (MM "Palliative Medicine") OR (MM "Terminally Ill") OR (MM "Terminal Care+") OR (MM "Hospice Care") OR TI "Palliat*" OR AB "Palliat*" OR TI "Terminal*" OR AB "Terminal*" OR TI "Hospice*" OR AB "Hospice*" OR TI "end of life care" OR AB "end of life care"	515,481
S27	(MH "Delivery of Health Care+") OR (MH "Health Services+") OR (MH "Cancer Care Facilities") OR (MH "Oncology Service, Hospital")	2,373,583
S28	AB "service*" OR TI "service*" OR AB "facilit*" OR TI "facilit"	895,555

S29	TX "interven*" OR AB "interven*" OR TI "interven*" OR TX "strateg*" OR AB "strateg*" OR TI "strateg*" OR TX "program*" OR AB "program*" OR TI "program*" OR TX "approach*" OR AB "approach*" OR TI "approach"	4,763,148
S30	TX "innovat*" OR AB "innovat*" OR TI "innovat*" OR TX "initiati*" OR AB "initiati*" OR TI "initiati*" OR TX "develop*" OR AB "develop*" OR TI "develop"	5,957,329
S31	TI "access*" OR AB "access*" OR TX "access*" OR TI "deliver*" OR AB "deliver*" OR TX "deliver*" OR TI "availab*" OR AB "availab*" OR TX "availab"	3,459,668
S32	AB "perspectiv*" OR TI "perspectiv*" OR AB "exper*" OR TI "exper*" OR AB "statu*" OR TI "statu"	3,501,128
S33	S27 OR S28 OR S29 OR S30 OR S31 OR S32	12,456,599
S34	(MH "Primary Prevention+") OR (MH "School Health Services+") OR (MH "Health Education+") OR (MH "Diagnostic Services+")	424,273
S35	(MH "Diagnosis+")	7,562,779
S36	TI "Prevent*" OR TI "Screen*" OR TI "Early Detect*" OR TI "Aware"	418,936
S37	(MH "Animal Experimentation+")	8,320
S38	(MH "Animals+") OR (MH "Plants+")	21,153,285
S39	S10 AND S13 AND S16 AND S33	5,230
S40	S10 AND S13 AND S19 AND S33	1,907
S41	S10 AND S13 AND S22 AND S33	5,108
S42	S10 AND S13 AND S25 AND S33	1,133
S43	S10 AND S13 AND S26 AND S33	1,219
S44	S34 OR S35 OR S36 OR S37 OR S38	21,541,484
S45	S10 AND S13 AND S16 AND S33 NOT S44	576
S46	S10 AND S13 AND S19 AND S33 NOT S44	176
S47	S10 AND S13 AND S22 AND S33 NOT S44	491
S48	S10 AND S13 AND S25 AND S33 NOT S44	97
S49	S10 AND S13 AND S26 AND S33 NOT S44	139
S50	Surgery: S10 AND S13 AND S16 AND S33 NOT S44 (Limiters - Date of Publication: 19900101-20171231; English Language)	556
S51	Radiotherapy: S10 AND S13 AND S19 AND S33 NOT S44 (Limiters - Date of Publication: 19900101-20171231; English Language)	170

S52	Chemotherapy: S10 AND S13 AND S22 AND S33 NOT S44 (Limiters - Date of Publication: 19940101-20171231; English Language)	476
S53	Other essential cancer medicines: S10 AND S13 AND S25 AND S33 NOT S44 (Limiters - Date of Publication: 19900101-20171231; English Language)	93
S54	Palliative Care: S10 AND S13 AND S26 AND S33 NOT S44 (Limiters - Published Date: 19900101-20171231; English Language)	135

Database 2: CINHAL (EBSCO) Search Strategy

Search ID	Search Term	Hits
S1	(MH "Afghanistan") OR (MH "Benin") OR (MH "Burkina Faso") OR (MH "Burundi") OR (MH "Central African Republic") OR (MH "Chad") OR (MH "Democratic Republic of the Congo") OR (MH "Eritrea") OR (MH "Ethiopia") OR (MH "Gambia") OR (MH "Guinea") OR (MH "Guinea-Bissau") OR (MH "Haiti") OR (MH "North Korea") OR (MH "Liberia") OR (MH "Madagascar") OR (MH "Malawi") OR (MH "Mali") OR (MH "Mozambique") OR (MH "Nepal") OR (MH "Niger") OR (MH "Rwanda") OR (MH "Senegal") OR (MH "Sierra Leone") OR (MH "Somalia") OR (MH "Sudan") OR (MH "Tanzania") OR (MH "Togo") OR (MH "Uganda") OR (MH "Zimbabwe") OR (MH "Armenia") OR (MH "Bangladesh") OR (MH "Bhutan") OR (MH "Bolivia") OR (MH "Cape Verde") OR (MH "Cambodia") OR (MH "Cameroon") OR (MH "Congo") OR (MH "Cote d'Ivoire") OR (MH "Djibouti") OR (MH "Egypt") OR (MH "El Salvador") OR (MH "Ghana") OR (MH "Guatemala") OR (MH "Honduras") OR (MH "India") OR (MH "Indonesia") OR (MH "Kenya") OR (MH "Laos") OR (MH "Lesotho") OR (MH "Mauritania") OR (MH "Micronesia") OR (MH "Moldova") OR (MH "Mongolia") OR (MH "Morocco") OR (MH "Myanmar") OR (MH "Nicaragua") OR (MH "Nigeria") OR (MH "Pakistan") OR (MH "Papua New Guinea") OR (MH "Philippines") OR (MH "Samoa") OR (MH "Sri Lanka") OR (MH "Swaziland") OR (MH "Syria") OR (MH "Tajikistan") OR (MH "Timor") OR (MH "Tunisia") OR (MH "Ukraine") OR (MH "Uzbekistan") OR (MH "Vietnam") OR (MH "Yemen") OR (MH "Zambia") OR (MH "Albania") OR (MH "American Samoa") OR (MH "Angola") OR (MH "Azerbaijan") OR (MH "Byelarus") OR (MH "Belize") OR (MH "Bosnia-Herzegovina") OR (MH "Botswana") OR (MH "Brazil") OR (MH "Bulgaria") OR (MH "China") OR (MH "Colombia") OR (MH "Costa Rica") OR (MH "Cuba") OR (MH "Dominica") OR (MH "Dominican Republic") OR (MH "Equatorial Guinea") OR (MH "Ecuador") OR (MH "Gabon") OR (MH "Georgia") OR (MH "Guyana") OR (MH "Iran") OR (MH "Iraq") OR (MH "Jamaica") OR (MH "Jordan") OR (MH "Kazakhstan") OR (MH "Lebanon") OR (MH "Libya") OR (MH "Macedonia (Republic)") OR (MH "Malaysia") OR (MH "Mexico") OR (MH "Namibia") OR (MH "Panama") OR (MH "Paraguay") OR (MH "Peru") OR (MH "Romania") OR (MH "Serbia") OR (MH "South Africa") OR (MH "Suriname") OR (MH "Thailand") OR (MH "Turkey") OR (MH "Turkmenistan") OR (MH "Venezuela")	131,991
S2	(MH "Developing Countries") OR (MH "Low and Middle Income Countries")	9,418
S3	(MH "Asia, Southeastern+") OR (MH "Asia, Central+") OR (MH "Asia, Northern+") OR (MH "Asia, Western+") OR (MH "Africa+") OR (MH "Central America+") OR (MH "South America+")	124,122
S4	TI Afghanistan OR TI "Benin" OR TI "Burkina Faso" OR TI "Burundi" OR TI "Central African Republic" OR TI "Chad" OR TI "Democratic Republic of the Congo" OR TI "Eritrea" OR TI "Ethiopia" OR TI "Gambia" OR TI "Guinea" OR TI "Guinea-Bissau"	2,731
S5	TI "North Korea" OR TI "Liberia" OR TI "Madagascar" OR TI "Malawi" OR TI "Mali" OR TI "Mozambique" OR TI "Nepal" OR TI "Niger" OR TI "Rwanda" OR TI "Senegal" OR TI "Sierra Leone" OR TI "Somalia"	2,507

S6	TI "Tanzania" OR TI "Togo" OR TI "Uganda" OR TI "Zimbabwe" OR TI "Armenia" OR TI "Bangladesh" OR TI "Bhutan" OR TI "Bolivia" OR TI "Cape Verde" OR TI "Cambodia" OR TI "Cameroon" OR TI "Congo"	4,168
S7	TI "Cote d'Ivoire" OR TI "Djibouti" OR TI "Egypt" OR TI "El Salvador" OR TI "Ghana" OR TI "Guatemala" OR TI "Honduras" OR TI "India" OR TI "Indonesia" OR TI "Kenya" OR TI "Lesotho" OR TI "Mauritania"	7,669
S8	TI "Micronesia" OR TI "Moldova" OR TI "Mongolia" OR TI "Morocco" OR TI "Myanmar" OR TI "Nicaragua" OR TI "Nigeria" OR TI "Pakistan" OR TI "Papua New Guinea" OR TI "Philippines" OR TI "Samoa" OR TI "Sri Lanka"	4,158
S9	TI "Sudan" OR TI "Swaziland" OR TI "Syria" OR TI "Tajikistan" OR TI "Timor" OR TI "Tunisia" OR TI "Ukraine" OR TI "Uzbekistan" OR TI "Vietnam" OR TI "Yemen" OR TI "Zambia" OR TI "Albania"	2,583
S10	TI "Algeria" OR TI "American Samoa" OR TI "Angola" OR TI "Argentina" OR TI "Azerbaijan" OR TI "Republic of Byelarus" OR TI "Belize" OR TI "Bosnia-Herzegovina" OR TI "Botswana" OR TI "Brazil" OR TI "Bulgaria" OR TI "Colombia"	4,527
S11	TI "China" OR TI "Costa Rica" OR TI "Cuba" OR TI "Dominica" OR TI "Dominican Republic" OR TI "Equatorial Guinea" OR TI "Ecuador" OR TI "Gabon" OR TI "Georgia" OR TI "Iran" OR TI "Guyana" OR TI "Iraq"	10,422
S12	TI "Jamaica" OR TI "Jordan" OR TI "Kazakhstan" OR TI "Lebanon" OR TI "Libya" OR TI "Macedonia (Republic)" OR TI "Macedonia (Republic)" OR TI "Malaysia" OR TI "Mexico" OR TI "Namibia" OR TI "Panama" OR TI "Paraguay"	4,388
S13	TI "Peru" OR TI "Romania" OR TI "Serbia" OR TI "South Africa" OR TI "Suriname" OR TI "Thailand" OR TI "Turkey" OR TI "Turkmenistan" OR TI "Venezuela"	6,490
S14	TI "third world countr*" OR AB "third world countr*" OR TI "less-developed countr*" OR AB "less-developed countr*" OR TI "under developed countr*" OR AB "under developed countr*" OR TI "developing nation*" OR AB "developing nation*" OR TI "less developed nation*" OR AB "less developed nation"	665
S15	TI "third world nation*" OR AB "third world nation*" OR TI "underdeveloped nation*" OR AB "underdeveloped nation*" OR TI "developing countr*" OR AB "developing countr*" OR TI "low income countr*" OR AB "low income countr*" OR TI "middle income countr*" OR AB "middle income countr*" OR TI "middle income nation*" OR AB "middle income nation"	8,499
S16	TI ("low and middle income") OR AB ("low and middle income") OR TI "resource limited countr*" OR AB "resource limited countr*" OR TI "resource limited set*" OR AB "resource limited set*" OR AB "Imic*" OR "Imic"	2,071
S17	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16	172,446
S18	(MH "Australia") OR (MH "Andorra") OR (MH "Austria") OR (MH "Belgium") OR (MH "Albania") OR (MH "Germany") OR (MH "Netherlands") OR (MH "Portugal") OR (MH "Switzerland") OR (MH "Spain") OR (MH "United Kingdom+") OR (MH "Luxembourg") OR (MH "Liechtenstein") OR (MH "Italy") OR (MH "Taiwan") OR (MH "South Korea") OR (MH "Japan") OR (MH "Hong Kong") OR (MH "Ireland") OR (MH "France") OR (MH "Kuwait") OR (MH "United Arab Emirates") OR (MH "Oman") OR (MH "Qatar") OR (MH "Saudi Arabia")	388,137
S19	S17 NOT S18	160,334

S20	(MH "Neoplasms+")	223,850
S21	TI "cancer*" OR AB "cancer*" OR TI "tumo*" OR AB "tumo*" OR TI "malignan*" OR AB "malignan*"	201,872
S22	S20 OR S21	289,535
S23	(MH "Surgery, Operative") OR (MH "Oncology") OR (MH "Oncology Surgery")	16,034
S24	TI "surger*" OR AB "surger*" OR TI "oncolog*" OR AB "oncolog*"	115,669
S25	S23 OR S24	125,845
S26	(MH "Radiotherapy+") OR (MH "Oncology") OR (MH "Radiation Oncology")	16,485
S27	TI "Radiotherap*" OR AB "Radiotherap*" OR TI "Brachytherap*" OR AB "Brachytherap*" OR TI "Radiat*" OR AB "Radiat*" OR TI ("external beam radiotherapy") OR AB ("external beam radiotherapy")	24,661
S28	S26 OR S27	33,805
S29	(MH "Drug Therapy") OR (MH "Chemotherapy, Cancer") OR (MH "Chemotherapy, Adjuvant") OR (MH "Antineoplastic Agents, Combined")	29,635
S30	TI "chemotherap*" OR AB "chemotherap*" OR TI "drug*" OR AB "drug*" OR TI "pharmac*" OR AB "pharmac*" OR TI "anticancer*" OR AB "anticancer*" OR TI "anti-cancer*" OR AB "anti-cancer*" OR TI "anti-tumo*" OR AB "anti-tumo*"	187,111
S31	S29 OR S30	202,393
S32	(MH "Immunotherapy") OR (MH "Hormone Therapy")	4,455
S33	TI "immunotherap*" OR AB "immunotherap*" OR TI "Hormon*" OR AB "Hormon*"	24,670
S34	S32 OR S33	27,144
S35	(MH "Palliative Care") OR (MH "Terminal Care") OR (MH "Hospice Care")	36,597
S36	TI "palliat*" OR AB "palliat*" OR TI "terminal*" OR AB "terminal*" OR TI "hospice*" OR AB "hospice*" OR TI ("end of life care") OR AB ("end of life care")	39,985
S37	S35 OR S36	54,035
S38	(MH "Health Care Delivery+") OR MH "Health Services+" OR (MH "Cancer Care Facilities") OR (MH "Oncologic Care")	767,257

S39	TI "service*" OR AB "service*" OR TI "facilit*" OR AB "facilit*" OR TI "interven*" OR AB "interven*" OR TI "strateg*" OR AB "strateg*" OR TI "program*" OR AB "program*" OR TI "approach*" OR AB "approach"	699,000
S40	TI "innovat*" OR AB "innovat*" OR TI "initiati*" OR AB "initiati*" OR TI "develop*" OR AB "develop*" OR TI "access*" OR AB "access*" OR TI "deliver*" OR AB "deliver*" OR TI "availab*" OR AB "availab"	573,553
S41	TI "perspectiv*" OR AB "perspectiv*" OR TI "exper*" OR AB "exper*" OR TI "statu*" OR AB "statu"	435,795
S42	S38 OR S39 OR S40 OR S41	1,645,797
S43	(MH "Diagnostic Services+") OR (MH "Diagnosis+") OR (MH "Health Education+") OR (MH "Patient Education+") OR (MH "School Health Services+") OR (MH "Student Health Services+")	913,774
S44	TI "Prevent*" OR TI "Screen*" OR TI "Screen*" OR TI "Early Detect*" OR TI "Aware"	101,355
S45	(MH "Animals+")	35,360
S46	(MH "Plants+")	54,845
S47	S43 OR S44 OR S45 OR S46	1,037,898
S48	S19 AND S22 AND S25 AND S42 NOT S47	506
S49	S19 AND S22 AND S28 AND S42 NOT S47	172
S50	S19 AND S22 AND S31 AND S42 NOT S47	418
S51	S19 AND S22 AND S34 AND S42 NOT S47	42
S52	S19 AND S22 AND S37 AND S42 NOT S47	362
S53	Surgery: S19 AND S22 AND S25 AND S42 NOT S47 (19900101-20171231 Narrow by Language: - english)	432
S54	Radiotherapy: S19 AND S22 AND S28 AND S42 NOT S47 (19900101-20171231 Narrow by Language: - english)	155
S55	Chemotherapy: S19 AND S22 AND S31 AND S42 NOT S47 (19900101-20171231 Narrow by Language: - english)	359
S56	Other essential cancer medicines: S19 AND S22 AND S34 AND S42 NOT S47 (19900101-20171231 Narrow by Language: - english)	41

S57	Palliative Care: S19 AND S22 AND S37 AND S42 NOT S47 (19900101-20171231 Narrow by Language: - english)	329
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Database 3: Cochrane Library Search Strategy

	Search ID	Search Terms	Hits
#	1	MeSH descriptor: [Afghanistan] explode all trees	34
#	2	MeSH descriptor: [Benin] explode all trees	45
#	3	MeSH descriptor: [Burkina Faso] explode all trees	111
#	4	MeSH descriptor: [Burundi] explode all trees	9
#	5	MeSH descriptor: [Central African Republic] explode all trees	10
#	6	MeSH descriptor: [Chad] explode all trees	5
#	7	MeSH descriptor: [Comoros] explode all trees	1
#	8	MeSH descriptor: [Congo] explode all trees	12
#	9	MeSH descriptor: [Eritrea] explode all trees	2
#	10	MeSH descriptor: [Ethiopia] explode all trees	139
#	11	MeSH descriptor: [Gambia] explode all trees	208
#	12	MeSH descriptor: [Guinea] explode all trees	6
#	13	MeSH descriptor: [Guinea-Bissau] explode all trees	79
#	14	MeSH descriptor: [Haiti] explode all trees	50
#	15	MeSH descriptor: [Democratic People's Republic of Korea] explode all trees	3
#	16	MeSH descriptor: [Liberia] explode all trees	14
#	17	MeSH descriptor: [Madagascar] explode all trees	34
#	18	MeSH descriptor: [Malawi] explode all trees	249
#	19	MeSH descriptor: [Mali] explode all trees	75
#	20	MeSH descriptor: [Mozambique] explode all trees	67
#	21	MeSH descriptor: [Nepal] explode all trees	221

#	22	MeSH descriptor: [Niger] explode all trees	32
#	23	MeSH descriptor: [Rwanda] explode all trees	42
#	24	MeSH descriptor: [Senegal] explode all trees	82
#	25	MeSH descriptor: [Sierra Leone] explode all trees	26
#	26	MeSH descriptor: [Somalia] explode all trees	9
#	27	MeSH descriptor: [Sudan] explode all trees	81
#	28	MeSH descriptor: [Tanzania] explode all trees	469
#	29	MeSH descriptor: [Togo] explode all trees	12
#	30	MeSH descriptor: [Zimbabwe] explode all trees	158
#	31	MeSH descriptor: [Armenia] explode all trees	8
#	32	MeSH descriptor: [Bangladesh] explode all trees	490
#	33	MeSH descriptor: [Bhutan] explode all trees	1
#	34	MeSH descriptor: [Bolivia] explode all trees	35
#	35	MeSH descriptor: [Cape Verde] explode all trees	0
#	36	MeSH descriptor: [Cambodia] explode all trees	83
#	37	MeSH descriptor: [Cameroon] explode all trees	94
#	38	MeSH descriptor: [Congo] explode all trees	12
#	39	MeSH descriptor: [Cote d'Ivoire] explode all trees	75
#	40	MeSH descriptor: [Djibouti] explode all trees	1
#	41	MeSH descriptor: [Egypt] explode all trees	291
#	42	MeSH descriptor: [El Salvador] explode all trees	3
#	43	MeSH descriptor: [Ghana] explode all trees	230
#	44	MeSH descriptor: [Guatemala] explode all trees	109
#	45	MeSH descriptor: [Honduras] explode all trees	33
#	46	MeSH descriptor: [India] explode all trees	1772
#	47	MeSH descriptor: [Indonesia] explode all trees	267

#	48	MeSH descriptor: [Kenya] explode all trees	560
#	49	MeSH descriptor: [Micronesia] explode all trees	2
#	50	MeSH descriptor: [Kyrgyzstan] explode all trees	4
#	51	MeSH descriptor: [Lesotho] explode all trees	2
#	52	MeSH descriptor: [Mauritania] explode all trees	2
#	53	MeSH descriptor: [Micronesia] explode all trees	2
#	54	MeSH descriptor: [Moldova] explode all trees	1
#	55	MeSH descriptor: [Mongolia] explode all trees	16
#	56	MeSH descriptor: [Morocco] explode all trees	32
#	57	MeSH descriptor: [Myanmar] explode all trees	53
#	58	MeSH descriptor: [Nicaragua] explode all trees	25
#	59	MeSH descriptor: [Nigeria] explode all trees	492
#	60	MeSH descriptor: [Pakistan] explode all trees	338
#	61	MeSH descriptor: [Papua New Guinea] explode all trees	54
#	62	MeSH descriptor: [Philippines] explode all trees	137
#	63	MeSH descriptor: [Samoa] explode all trees	4
#	64	MeSH descriptor: [Atlantic Islands] explode all trees	2
#	65	MeSH descriptor: [Sri Lanka] explode all trees	83
#	66	MeSH descriptor: [Swaziland] explode all trees	7
#	67	MeSH descriptor: [Syria] explode all trees	14
#	68	MeSH descriptor: [Tajikistan] explode all trees	2
#	69	MeSH descriptor: [Timor-Leste] explode all trees	1
#	70	MeSH descriptor: [Tonga] explode all trees	1
#	71	MeSH descriptor: [Tunisia] explode all trees	46
#	72	MeSH descriptor: [Ukraine] explode all trees	46
#	73	MeSH descriptor: [Uzbekistan] explode all trees	7

#	74	MeSH descriptor: [Vanuatu] explode all trees	4
#	75	MeSH descriptor: [Vietnam] explode all trees	292
#	76	MeSH descriptor: [Yemen] explode all trees	7
#	77	MeSH descriptor: [Zambia] explode all trees	223
#	78	MeSH descriptor: [Albania] explode all trees	3
#	79	MeSH descriptor: [Algeria] explode all trees	8
#	80	MeSH descriptor: [American Samoa] explode all trees	4
#	81	MeSH descriptor: [Angola] explode all trees	9
#	82	MeSH descriptor: [Argentina] explode all trees	179
#	83	MeSH descriptor: [Azerbaijan] explode all trees	4
#	84	MeSH descriptor: [Republic of Belarus] explode all trees	26
#	85	MeSH descriptor: [Belize] explode all trees	8
#	86	MeSH descriptor: [Bosnia and Herzegovina] explode all trees	9
#	87	MeSH descriptor: [Botswana] explode all trees	47
#	88	MeSH descriptor: [Brazil] explode all trees	1129
#	89	MeSH descriptor: [Bulgaria] explode all trees	36
#	90	MeSH descriptor: [China] explode all trees	3530
#	91	MeSH descriptor: [Colombia] explode all trees	141
#	92	MeSH descriptor: [Costa Rica] explode all trees	35
#	93	MeSH descriptor: [Cuba] explode all trees	53
#	94	MeSH descriptor: [Dominica] explode all trees	0
#	95	MeSH descriptor: [Dominican Republic] explode all trees	29
#	96	MeSH descriptor: [Equatorial Guinea] explode all trees	3
#	97	MeSH descriptor: [Ecuador] explode all trees	61
#	98	MeSH descriptor: [Fiji] explode all trees	9
#	99	MeSH descriptor: [Gabon] explode all trees	40

#	100	MeSH descriptor: [Georgia] explode all trees	205
#	101	MeSH descriptor: [Grenada] explode all trees	0
#	102	MeSH descriptor: [Guyana] explode all trees	3
#	103	MeSH descriptor: [Iran] explode all trees	843
#	104	MeSH descriptor: [Iraq] explode all trees	42
#	105	MeSH descriptor: [Jamaica] explode all trees	59
#	106	MeSH descriptor: [Jordan] explode all trees	46
#	107	MeSH descriptor: [Kazakhstan] explode all trees	6
#	108	MeSH descriptor: [Lebanon] explode all trees	41
#	109	MeSH descriptor: [Libya] explode all trees	5
#	110	MeSH descriptor: [Macedonia (Republic)] explode all trees	4
#	111	MeSH descriptor: [Malaysia] explode all trees	227
#	112	MeSH descriptor: [Indian Ocean Islands] explode all trees	134
#	113	MeSH descriptor: [Mauritius] explode all trees	1
#	114	MeSH descriptor: [Mexico] explode all trees	558
#	115	MeSH descriptor: [Montenegro] explode all trees	1
#	116	MeSH descriptor: [Namibia] explode all trees	8
#	117	MeSH descriptor: [Palau] explode all trees	0
#	118	MeSH descriptor: [Panama] explode all trees	11
#	119	MeSH descriptor: [Paraguay] explode all trees	3
#	120	MeSH descriptor: [Peru] explode all trees	180
#	121	MeSH descriptor: [Romania] explode all trees	89
#	122	MeSH descriptor: [Russia] explode all trees	320
#	123	MeSH descriptor: [Siberia] explode all trees	13
#	124	MeSH descriptor: [South Africa] explode all trees	924
#	125	MeSH descriptor: [Saint Lucia] explode all trees	0

#	126	MeSH descriptor: [Saint Vincent and the Grenadines] explode all trees	0
#	127	MeSH descriptor: [Suriname] explode all trees	13
#	128	MeSH descriptor: [Thailand] explode all trees	1023
#	129	MeSH descriptor: [Turkey] explode all trees	666
#	130	MeSH descriptor: [Turkmenistan] explode all trees	1
#	131	MeSH descriptor: [Venezuela] explode all trees	49
#	132	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 or #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 or #74 or #75 or #76 or #77 or #78 or #79 or #80 or #81 or #82 or #83 or #84 or #85 or #86 or #87 or #88 or #89 or #90 or #91 or #92 or #93 or #94 or #95 or #96 or #97 or #98 or #99 or #100 or #101 or #102 or #103 or #104 or #105 or #106 or #107 or #108 or #109 or #110 or #111 or #112 or #113 or #114 or #115 or #116 or #117 or #118 or #119 or #120 or #121 or #122 or #123 or #124 or #125 or #126 or #127 or #128 or #129 or #130 or #131	18232
#	133	MeSH descriptor: [Developing Countries] explode all trees	1013
#	134	MeSH descriptor: [Asia, Southeastern] explode all trees	2316
#	135	MeSH descriptor: [Asia, Central] explode all trees	25
#	136	MeSH descriptor: [Asia, Western] explode all trees	5293
#	137	MeSH descriptor: [Africa] explode all trees	5879
#	138	Afghanistan:ti or Benin:ti or Burkina Faso:ti or Burundi:ti or Central African Republic:ti (Word variations have been searched)	249
#	139	Chad:ti or Comoros:ti or Congo:ti or Eritrea:ti or Ethiopia:ti (Word variations have been searched)	295
#	140	Gambia:ti or Guinea:ti or Guinea-Bissau:ti or Haiti:ti or Korea:au (Word variations have been searched)	369
#	141	Liberia:ti or Madagascar:ti or Malawi:ti or Mali:ti or Mozambique:ti (Word variations have been searched)	456
#	142	Nepal:ti or Niger:ti or Rwanda:ti or Senegal:ti or Sierra Leone:ti (Word variations have been searched)	493
#	143	Somalia:ti or Sudan:ti or Tanzania:ti or Togo:ti or Uganda:ti (Word variations have been searched)	1065
#	144	Zimbabwe:ti or Armenia:ti or Bangladesh:ti or Bhutan:ti or Bolivia:ti (Word variations have been searched)	606
#	145	Cape Verde:ti or Cambodia:ti or Cameroon:ti or Côte d'Ivoire:ti or Djibouti:ti (Word variations have been searched)	252
#	146	Egypt:ti or El Salvador:ti or Ghana:ti or Guatemala:ti or Honduras:ti (Word variations have been searched)	419
#	147	India:ti or Indonesia:ti or Kenya:ti or Kiribati:ti or Kosovo:ti (Word variations have been searched)	1931

#	148	Kyrgyz Republic:ti or Lao:ti or Lesotho:ti or Mauritania:ti or Micronesia:ti (Word variations have been searched)	47
#	149	Moldova:ti or Mongolia:ti or Morocco:ti or Myanmar:ti or Nicaragua:ti (Word variations have been searched)	119
#	150	Nigeria:ti or Pakistan:ti and Papua New Guinea:ti or Philippines:ti or Samoa:ti (Word variations have been searched)	404
#	151	Sao Tome and Principe:ti or Solomon Islands:ti or Sri Lanka:ti or Swaziland:ti or Syria:ti (Word variations have been searched)	99
#	152	Tajikistan:ti or Timor-Leste:ti or Tonga:ti or Tunisia:ti or Ukraine:ti (Word variations have been searched)	50
#	153	Uzbekistan:ti or Vanuatu:ti or Vietnam:ti or West Bank and Gaza:ti or Yemen:ti (Word variations have been searched)	255
#	154	Zambia:ti or Albania:ti or Algeria:ti or American Samoa:ti or Angola:ti (Word variations have been searched)	194
#	155	Argentina:ti or Azerbaijan:ti or Belarus:ti or Belize:ti or "Bosnia and Herzegovina":ti (Word variations have been searched)	127
#	156	Botswana:ti or Brazil:ti or Bulgaria:ti or China:ti or Colombia:ti (Word variations have been searched)	2329
#	157	"Costa Rica":ti or Cuba:ti or Dominica:ti or "Dominican Republic":ti or "Equatorial Guinea":ti (Word variations have been searched)	74
#	158	Ecuador:ti or Fiji:ti or Gabon:ti or Georgia:ti or Grenada:ti (Word variations have been searched)	122
#	159	Guyana:ti or Iran:ti or Iraq:ti or Jamaica:ti or Jordan:ti (Word variations have been searched)	508
#	160	Kazakhstan:ti or Lebanon:ti or Libya:ti or Macedonia:ti or Malaysia:ti (Word variations have been searched)	199
#	161	Maldives:ti or Marshall Islands:ti or Mauritius:ti or Mexico:ti or Montenegro:ti (Word variations have been searched)	335
#	162	Namibia:ti or Palau:ti or Panama:ti or Paraguay:ti or Peru:ti (Word variations have been searched)	192
#	163	Romania:ti or Russian:ti or Serbia:ti or South Africa:ti or St. Lucia:ti (Word variations have been searched)	1012
#	164	St. Vincent and the Grenadines:ti or Suriname:ti or Thailand:ti or Turkey:ti or Turkmenistan:ti (Word variations have been searched)	712
#	165	Tuvalu:ti or Venezuela:ti (Word variations have been searched)	35
#	166	"third world countr*":ti or "less-developed countr*":ti or "under developed count*":ti or "developing nation*":ti or "less developed nation*":ti (Word variations have been searched)	18
#	167	"third world nation*":ti or "underdeveloped nation*":ti or "developing countr*":ti or "low income countr*":ti or "middle income countr*":ti (Word variations have been searched)	618
#	168	"middle income nation*":ti or "low and middle income":ti or "resource limited countr*":ti or "resource limited set*":ti or "lmic*":ti (Word variations have been searched)	267
#	169	#132 or #133 or #134 or #135 or #136 or #137 or #138 or #139 or #140 or #141 or #142 or #143 or #144 or #145 or #146 or #147 or #148 or #149 or #150 or #151 or #152 or #153 or #154 or #155 or #156 or #157 or #158 or #159 or #160 or #161 or #162 or #163 or #164 or #165 or #166 or #167 or #168	27755
#	170	MeSH descriptor: [Australia] explode all trees	3500
#	171	MeSH descriptor: [Austria] explode all trees	381

#	172	MeSH descriptor: [Belgium] explode all trees	549
#	173	MeSH descriptor: [Albania] explode all trees	1
#	174	MeSH descriptor: [Germany] explode all trees	2914
#	175	MeSH descriptor: [Netherlands] explode all trees	3169
#	176	MeSH descriptor: [Portugal] explode all trees	131
#	177	MeSH descriptor: [Switzerland] explode all trees	639
#	178	MeSH descriptor: [Spain] explode all trees	1371
#	179	MeSH descriptor: [Great Britain] explode all trees	6119
#	180	MeSH descriptor: [Luxembourg] explode all trees	4
#	181	MeSH descriptor: [Liechtenstein] explode all trees	0
#	182	MeSH descriptor: [Italy] explode all trees	1932
#	183	MeSH descriptor: [Taiwan] explode all trees	885
#	184	MeSH descriptor: [Japan] explode all trees	2527
#	185	MeSH descriptor: [Hong Kong] explode all trees	566
#	186	MeSH descriptor: [Ireland] explode all trees	253
#	187	MeSH descriptor: [France] explode all trees	1418
#	188	MeSH descriptor: [Kuwait] explode all trees	27
#	189	MeSH descriptor: [United Arab Emirates] explode all trees	17
#	190	MeSH descriptor: [Oman] explode all trees	13
#	191	MeSH descriptor: [Qatar] explode all trees	6
#	192	MeSH descriptor: [Saudi Arabia] explode all trees	149
#	193	#170 or #171 or #172 or #173 or #174 or #175 or #176 or #177 or #178 or #179 or #180 or #181 or #182 or #183 or #184 or #185 or #186 or #187 or #188 or #189 or #190 or #191 or #192	25780
#	194	#169 not #193	26555
#	195	MeSH descriptor: [Neoplasms] explode all trees	61678
#	196	"cancer*":ti,ab,kw or "tumo*":ti,ab,kw or "malignan*":ti,ab,kw (Word variations have been searched)	118517
#	197	#195 or #196	134738

#	198	MeSH descriptor: [General Surgery] explode all trees	363
#	199	MeSH descriptor: [Medical Oncology] explode all trees	243
#	200	"surger*":ti,ab,kw or "oncolog*":ti,ab,kw (Word variations have been searched)	124693
#	201	#198 or #199 or #200	124693
#	202	MeSH descriptor: [Radiotherapy] explode all trees	6198
#	203	MeSH descriptor: [Radiation Oncology] explode all trees	50
#	204	"radiotherap*":ti,ab,kw or "brachytherap*":ti,ab,kw or "radiat*":ti,ab,kw or "external beam radiotherapy":ti,ab,kw (Word variations have been searched)	27146
#	205	#202 or #203 or #204	6198
#	206	MeSH descriptor: [Drug Therapy] explode all trees	133128
#	207	MeSH descriptor: [Drug Therapy, Combination] explode all trees	42315
#	208	MeSH descriptor: [Antineoplastic Agents] explode all trees	12138
#	209	"chemotherap*":ti,ab,kw or "drug*":ti,ab,kw or "pharmac*":ti,ab,kw or "anticancer*":ti,ab,kw or "anti-tumo*":ti,ab,kw (Word variations have been searched)	381222
#	210	#206 or #207 or #208 or #209	419862
#	211	MeSH descriptor: [Immunotherapy] explode all trees	7864
#	212	MeSH descriptor: [Molecular Targeted Therapy] explode all trees	114
#	213	"immunotherap*":ti,ab,kw or "Hormon*":ti,ab,kw (Word variations have been searched)	43367
#	214	#211 or #212 or #213	49209
#	215	MeSH descriptor: [Palliative Care] explode all trees	1648
#	216	MeSH descriptor: [Hospice Care] explode all trees	109
#	217	MeSH descriptor: [Terminal Care] explode all trees	455
#	218	"palliat*":ti,ab,kw or "terminal*":ti,ab,kw or "hospice*":ti,ab,kw or "end of life care":ti,ab,kw (Word variations have been searched)	11605
#	219	#215 or #216 or #217 or #218	11631
#	220	MeSH descriptor: [Delivery of Health Care] explode all trees	45970
#	221	MeSH descriptor: [Health Services] explode all trees	90781
#	222	MeSH descriptor: [Cancer Care Facilities] explode all trees	90

#	223	"service*":ti,ab,kw or "facilit*":ti,ab,kw or "interven*":ti,ab,kw or "strateg*":ti,ab,kw or "program*":ti,ab,kw (Word variations have been searched)	237274
#	224	"approach*":ti,ab,kw or "innovat*":ti,ab,kw or "initiati*":ti,ab,kw or "develop*":ti,ab,kw or "access*":ti,ab,kw (Word variations have been searched)	166805
#	225	"deliver*":ti,ab,kw or "availab*":ti,ab,kw or "perspectiv*":ti,ab,kw or "exper*":ti,ab,kw or "statu*":ti,ab,kw (Word variations have been searched)	269256
#	226	#220 or #221 or #222 or #223 or #224 or #225	526337
#	227	MeSH descriptor: [Diagnostic Services] explode all trees	5666
#	228	MeSH descriptor: [Diagnosis] explode all trees	308313
#	229	MeSH descriptor: [Immunization] explode all trees	4827
#	230	MeSH descriptor: [Health Education] explode all trees	12187
#	231	MeSH descriptor: [Patient Education as Topic] explode all trees	8103
#	232	MeSH descriptor: [School Health Services] explode all trees	1341
#	233	MeSH descriptor: [Student Health Services] explode all trees	60
#	234	"Prevent*":ti or "Screen*":ti or "Early Detect*":ti or "Aware*":ti (Word variations have been searched)	49945
#	235	MeSH descriptor: [Animals] explode all trees	8252
#	236	MeSH descriptor: [Plants] explode all trees	10018
#	237	#227 or #228 or #229 or #230 or #231 or #231 or #232 or #233 or #234 or #235 or #236	363330
#	238	Surgery: #194 and #197 and #201 and #226 not #237	97
#	239	Radiotherapy: #194 and #197 and #205 and #226 not #237	6
#	240	Chemotherapy: #194 and #197 and #210 and #226 not #237	190
#	241	Other essential cancer medicines: #194 and #197 and #214 and #226 not #237	15
#	242	Palliative Care: #194 and #197 and #219 and #226 not #237	9

Appendix E: Semi-Structured Interviews Invitational Email

Ethics Reference Number: **ETH18-2187**

[Start email invitation]

Dear,

This email is to introduce Andrew Donkor, a radiation therapist from Ghana who is a doctoral student at the Faculty of Health, University of Technology Sydney. I am part of his supervisory team.

Andrew's doctoral research aims to identify the barriers and facilitators to radiotherapy service development, implementation and/or sustainability in low- and middle-income countries.

We would like to invite you to participate in a 30-45 minutes interview via Voice over Internet Protocols (VoIP) to explore your experience in strengthening radiotherapy services in low- and middle-income countries.

I have copied Andrew into this email. If you are interested, please email Andrew and he will provide you with more information about this qualitative study should you wish to find out more.

Thank you for considering this invitation.

Best wishes,

[End of email]

Email to be sent by:

Jane Phillips, RN PhD, FACN
Professor Palliative Nursing, Director IMPACCT
IMPACCT – Improving Palliative, Aged and Chronic Care through Clinical Research and Translation
Faculty of Health, UTS
T. +61 (02) 9514 4862 M. +61 [REDACTED]
Level 3, 235 Jones St. Ultimo NSW 2007
PO Box 123. Broadway NSW 2007 Australia

Or

Sanchia Aranda, RN PhD
Professor and CEO Cancer Council Australia
Faculty of Health, UTS
T. +61 (02) 8063 4111 Fax. +61 (02) 8063 4101
Level 14, 477 Pitt St. Sydney
PO Box 4708. NSW 2000 Australia

Appendix F: Participant Information Sheet

Ethics Reference Number: **ETH18-2187**

WHO IS DOING THE RESEARCH?

My name is Andrew Donkor and I am a doctoral student at UTS. My supervisors are Professor Jane Phillips, Doctor Tim Luckett and Professor Sanchia Aranda.

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about the barriers and facilitators to the successful development, implementation and/or sustainability of radiotherapy services in low- and middle-income countries. Our research seeks to explore the views of global and local radiotherapy experts with the intention to gain insights into multiple radiotherapy initiatives across a range of low- and middle-income countries.

FUNDING

This research is part of my doctoral project, which is funded by a UTS International Research Scholarship and UTS President's Scholarship.

WHY HAVE I BEEN ASKED?

You have been invited to participate in this study because of your expertise in strengthening radiotherapy services in low- and middle-income countries. Your contact details were obtained from international agencies, such as World Health Organisation, International Atomic Energy Agency, or Lancet Commission on Radiotherapy and Union for International Cancer Control.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to participate, you will be asked to partake in a 30-45 minutes semi-structured interview that will be audio recorded and transcribed. The interview will be conducted via telephone or Voice over Internet Protocols (VoIP). Before answering any question, you will be asked to give verbal consent on tape.

We will ask questions such as:

- Can you tell me about a project that you were involved in where you developed and implemented a radiotherapy service in a low- and middle-income country?
- Can you tell me about the barriers and facilitators?
- Can you tell me why the barriers and facilitators were important?
- Can you tell me what you would do differently next time?
- We will be interested to find out if there are other people who were involved in the project who might give a different perspective (e.g. local versus international).

You will be given the opportunity via email to verify or refute emerging themes in the analysis.

ARE THERE ANY RISKS/INCONVENIENCE?

The main risk from this study is the inconvenience caused by allocating 30-45 minutes to be interviewed. Participants will reserve the right not to answer any questions they prefer not to.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason, by contacting Andrew Donkor by email at

Andrew.Donkor@student.uts.edu.au. If you withdraw from the study prior to final reporting, the transcripts from your interview will be destroyed.

CONFIDENTIALITY

All the information you provide will be treated confidentially. Confidentiality will be protected by removing any personal identifying information from the transcripts. A master list will be created, and key informants will be assigned unique codes for easy identification and tracking. This list will be kept separately from any identifiable data in password protected electronic location. Only the research team will have access to the data. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

We plan to publish the results in a peer reviewed journal, as well as present it in international and local conferences. In any report, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisors can help you with, please feel free to contact us on:

- i. Andrew Donkor
IMPACCT, Faculty of Health
University of Technology Sydney
Building 10, Level 3, Room 300
Andrew.Donkor@student.uts.edu.au
+61 [REDACTED]
- ii. Prof. Jane Philips
Jane.Phillips@uts.edu.au
- iii. Dr. Tim Lockett
Tim.Lockett@uts.edu.au

You will be given a copy of this form to keep.

NOTE:

This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au, and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Appendix G: Participant Validation Invitational Email

Ethics Reference Number: **ETH18-2187**

[email invitation]

Dear Prof/Dr/Mr/Mrs....,

Thank you for participating in the interview held on [specific date for each expert] about barriers and facilitators to establishing radiotherapy services in low- and middle-income countries.

We've had the chance to analyse the data, which has led to several item requirements. We would be glad if you can help us confirm these item requirements by contributing to the next step of this project, which is to develop a guide to assess a country's 'readiness' for radiotherapy service development.

Based on this conversation, we have drafted a "*country-level radiotherapy service development readiness assessment guide*" to be used by LMIC's who are keen to establish a new radiotherapy service. This guide is designed to assist the team to identify the steps required and to identify any opportunities and barriers to establishing a radiotherapy service early in the planning process. This readiness assessment guide is intended to provide practical support for a more flexible planning approach by LMICs themselves, as well as by international agencies.

During our conversation, you spoke largely about building and sustaining strong political commitment, long-term financial strategy, maintenance approaches and leveraging off radiotherapy service to build a comprehensive cancer service. We suggest that you focus on commitment, capacity and catalyst requirements; however, feel free to review the other requirement if there is time [personalised for each expert].

The attached draft '*radiotherapy service development readiness self-assessment guide*' includes all of the item requirements generated from the interviews and literature review. Given its broad scope, I realise that there may be some items which are outside your experience that you don't feel able to comment on, so feel free to indicate this where appropriate. While the items are presented as being conceptually discrete, we recognise that establishing and sustaining a radiotherapy service is a process of continuous adaptation rather than one of linear progress.

Please see attached instructions for how to confirm the item requirements. If you prefer, there is an option to complete via a telephone interview instead. After you and others have completed this round of feedback, the plan is for me to revise the guide and then get back in touch for your further review. The document is still in development and has confidentially been shared with you.

I would of course be very happy to answer any questions you might have.

Thank you for considering this invitation.

Best wishes,

[End of email]

Email to be sent by:

Andrew Donkor,

On behalf of the research team.

Appendix H: Participant Validation Follow-Up Invitational Email

Ethics Reference Number: **ETH18-2187**

[email invitation]

Dear Prof/Dr/Mr/Mrs....,

This is with reference to our recent invitation email requesting for your participation in a participant validation study. We did not receive a reply from you. Please accept this follow-up invitation to participate in the validation study regarding the development and confirmation of readiness requirements and criteria for radiotherapy service establishment in low- and middle-income countries.

Your knowledge and experience in establishing, improving and/or delivering radiotherapy services in low- and middle-income countries will make a significant contribution to developing a readiness assessment guide.

Please refer to the initial invitational email below and attached information sheet for more information.

I would of course be very happy to answer any questions you might have.

Thank you for considering this invitation.

Best wishes,

[End of email]

Email to be sent by:

Andrew Donkor,

On behalf of the research team.

Appendix I: Ethics Application Approved as Low Risk

research.ethics@uts.edu.au

Mon 06/08/2018 20:16

Dear Applicant

Your local research office has reviewed your application titled, "Identifying key informants' perceptions of the barriers and facilitators for establishing sustainable radiotherapy services in low and middle-income countries: a qualitative study", and agreed that this application now meets the requirements of the National Statement on Ethical Conduct in Human Research (2007) and has been approved on that basis. You are therefore authorised to commence activities as outlined in your application, subject to any conditions detailed in this document.

You are reminded that this letter constitutes ethics approval only. This research project must also be undertaken in accordance with all UTS policies and guidelines including the Research Management Policy (<http://www.gsu.uts.edu.au/policies/research-management-policy.html>).

Your approval number is UTS HREC REF NO. ETH18-2187.

Approval will be for a period of five (5) years from the date of this correspondence subject to the submission of annual progress reports.

The following standard conditions apply to your approval:

- Your approval number must be included in all participant material and advertisements. Any advertisements on Staff Connect without an approval number will be removed.
- The Principal Investigator will immediately report anything that might warrant review of ethical approval of the project to the Ethics Secretariat (Research.Ethics@uts.edu.au).
- The Principal Investigator will notify the UTS HREC of any event that requires a modification to the protocol or other project documents, and submit any required amendments prior to implementation. Instructions can be found at <https://staff.uts.edu.au/topic/sub/Pages/Researching/Research%20Ethics%20and%20Integrity/Human%20research%20ethics/Post-approval/post-approval.aspx#tab2>.
- The Principal Investigator will promptly report adverse events to the Ethics Secretariat (Research.Ethics@uts.edu.au). An adverse event is any event (anticipated or otherwise) that has a negative impact on participants, researchers or the reputation of the University. Adverse events can also include privacy breaches, loss of data and damage to property.
- The Principal Investigator will report to the UTS HREC annually and notify the HREC when the project is completed at all sites. The Principal Investigator will notify the UTS HREC of any plan to extend the duration of the project past the approval period listed above through the progress report.
- The Principal Investigator will obtain any additional approvals or authorisations as required (e.g. from other ethics committees, collaborating institutions, supporting organisations).
- The Principal Investigator will notify the UTS HREC of his or her inability to continue as Principal Investigator including the name of and contact information for a replacement.

We also refer you to the AVCC guidelines relating to the storage of data, which require that data

be kept for a minimum of 5 years after publication of research. However, in NSW, longer retention requirements are required for research on human subjects with potential long-term effects, research with long-term environmental effects, or research considered of national or international significance, importance, or controversy. If the data from this research project falls into one of these categories, contact University Records for advice on long-term retention. You should consider this your official letter of approval.

If you have any queries about this approval, or require any amendments to your approval in future, please do not hesitate to contact your local research office or Research.Ethics@uts.edu.au.

REF: 12a

Appendix J: Publication and Permission to Re-Use Content – Semi-Structured Interviews (Study Two [Part A])

Donkor, A., Lockett, T., Aranda, S., Vanderpuye, V. & Phillips, J.L 2020, 'Experiences of barriers and facilitators to establishing and sustaining radiotherapy services in low- and middle-income countries: a qualitative study', *Asia-Pacific Journal of Clinical Oncology*, pp. 1-12.

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ORIGINAL ARTICLE

Experiences of barriers and facilitators to establishing and sustaining radiotherapy services in low- and middle-income countries: A qualitative study

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Correspondence

Andrew Donkor, Doctoral Candidate, IMPACTT (Improving Palliative, Aged and Chronic Care through Clinical Research and Translation), Faculty of Health, University of Technology Sydney, 235 Jones Street, Ultimo, NSW 2007, Australia.
Email: andrew.donkor@student.uts.edu.au

Abstract

Aims: The factors contributing to the establishment of high-quality radiotherapy services in low- and middle-income countries (LMICs) are poorly understood. The aim was to identify and describe barriers and facilitators to establishing and sustaining high-quality and accessible radiotherapy services in LMICs based on the experience of successful and unsuccessful attempts.**Methods:** An exploratory-descriptive qualitative study using semistructured telephone interviews was undertaken. Purposive and snowball sampling techniques were used to recruit participants. The World Health Organization Innovative Care for Chronic Conditions Framework informed the interview guide. A constant comparative data analysis approach was adopted.**Findings:** Seventeen participants were interviewed. Ten were working permanently in nine LMICs and seven were permanently employed in four high-income countries. Three themes were developed: committing to a vision of improving cancer care; making it happen and sustaining a safe service; and leveraging off radiotherapy to strengthen integrated cancer care. Identified barriers included lack of political leadership continuity, lack of a coordinated advocacy effort, non-Member State of the IAEA, lack of reliable epidemiological data, lack of a comprehensive budget and lack of local expertise. Facilitators identified included strong political support, vision champion, availability of a regulator, costed cancer control plan, diversified sources of funding, responsible project manager, adoption of evidence-based practice, strategic partnerships, motivation to provide patient-centered care, and availability of supportive technology.**Conclusions:** Assessing the level of readiness to establish and sustain a radiotherapy service is highly recommended. Future research is recommended to develop a readiness assessment tool for radiotherapy services implementation at LMICs.

KEYWORDS

implementation, low- and middle-income countries, neoplasm, radiotherapy, sustainability

1 | INTRODUCTION

Cancer is a major contributor to the global disease burden, particularly, in low- and middle-income countries (LMICs) with more than 10.3 million new cancer cases and 6.4 million cancer deaths in 2018. These numbers are projected to increase because of population growth, ageing, changes in lifestyle and socioeconomic development.¹ Radiotherapy is a critical component of cancer patients' management.In LMICs, almost two out of three cancer patients will require radiotherapy to cure or improve quality of life.²Achieving universal radiotherapy access is desirable, and global advocacy and supports are crucial.^{3,4} For more than six decades, the international community has worked collaboratively with LMICs to improve radiotherapy access.⁵ Efforts include the development of technical documents regarding safety, quality assurance, commissioning, and staffing of radiotherapy services.^{6–10} The Programme of

Innovative Care for Chronic Conditions Framework



FIGURE 1 Innovative care for chronic conditions framework adapted with permission granted by World Health Organization [Colour figure can be viewed at wileyonlinelibrary.com]

Action for Cancer Therapy (PACT) established by the International Atomic Energy Agency (IAEA) has been assisting LMICs to evaluate and plan their national cancer control programmes. Progress of PACT is attributed to the buy-in and commitment of the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC) to control cancer.¹¹ Global efforts also culminated in the Global Task Force on Radiotherapy for Cancer Control (GTRFCC), which quantified the investment required to achieve equity in radiotherapy access and the substantial return on that investment.⁴

It is important to assess candidate LMICs' readiness to establishing radiotherapy services and capacity to sustain these to avoid wasting limited resources. Assessing a country's readiness involves appraisal against likely barriers and facilitators related to policy, healthcare organization and community.¹² However, there has been a lack of empirical evidence to inform understanding of which factors might be important to consider. The aim of this study is to identify and describe barriers and facilitators to establishing and sustaining high-quality radiotherapy services in LMICs based on the experience of successful and unsuccessful attempts.

2 | METHODS AND ANALYSIS

2.1 | Study design

A descriptive qualitative design was used to develop an in-depth understanding of barriers and facilitators from the perspectives of people involved in introducing radiotherapy services in LMICs. Semistructured interviews were used to explore participants' experiences. The study design, data collection, analysis and reporting were conducted in accordance with consolidated criteria for reporting

qualitative research.¹³ The study was approved by the Human Research Ethics Committee at the University of Technology Sydney, and all participants gave verbal informed consent. Data collection took place between August 2018 and March 2019.

2.2 | Conceptual framework

The WHO Health System Building Blocks Framework for Action¹⁴ and Innovative Care for Chronic Condition Framework (ICCCF)¹⁵ informed the interview guide and the analysis framework (refer to Figure 1). The WHO Framework for Action is an internationally recognized building block for strengthening health systems and consists: service delivery; information; medical products, technologies; financing; and leadership and governance.¹⁴

2.3 | Participants and setting

Clinical/radiation oncologists, medical physicists, radiation therapists, and administrators primarily involved in establishing, strengthening, sustaining, and/or providing radiotherapy services in LMICs were eligible to participate in this study if they had: at least 2 years of experience; and spoke English. We excluded individuals who were involved with only high-income countries' (HICs) radiotherapy service improvements; had limited or no information about the radiotherapy initiative; and were unable to communicate in English.

2.4 | Recruitment of participants

A purposive sample using a snowball recruitment strategy was adopted to maximize the recruitment. Potential participants were recruited from the authors of relevant studies identified by a systematic

review,¹² international reports, recommendations, personal and professional networks. Participants were approached by AD, with an email introduction by SA or JP. The number of participants recruited into the study was determined by theoretical saturation.

2.5 | Data collection

All interviews were conducted in English via telephone by AD (a male radiation therapist from Ghana with limited experience but has completed training in qualitative research), with seven interviews assisted by TL/JP (male and female Australian clinical academics from allied health and nursing backgrounds respectively, with substantial experience in qualitative research). Interviewers had no previous or ongoing relationships with the people they interviewed. The interviews were facilitated by an interview guide informed by the literature¹² and ICCCF. The guide was pretested with an international radiotherapy expert from Australia. The pretest data was removed from the final analysis. All interviews were audiotaped and transcribed verbatim. Detailed interview notes were taken.

2.6 | Analysis

Integrated data analysis with inductive and deductive approaches was used to analyse the data.^{16,17} Transcripts were imported into NVivo version-12. Inductive analysis began with AD closely listening to each audio recording multiple times, reading and rereading the transcripts line-by-line to gain understanding.^{18,19} The researcher remained open to new themes and multiple meanings without a prespecified framework. Once a code was identified in the text, it was reused to capture new ideas in the text. Coded texts were grouped into categories reflecting the barriers and facilitators and they were discussed in a biweekly team meeting. Emerging themes were tested out in the interviews that followed.

Deductive analysis began by applying the ICCCF to provide a structured matrix, which allowed a systematic approach to data analysis.¹⁷ All data were indexed with identified codes and modified with the addition of new emergent ideas. The final coded results and categories with the transcripts were presented in a table and verified by the research team. Categories were synthesised into themes. To identify areas of convergence and discrepancy among participants, a constant comparison of themes was conducted.

Demographic data were analysed using descriptive statistics. To enhance trustworthiness, emerging themes were shared with selected participants for feedback.

3 | FINDINGS

Forty invitations were sent to potential participants and 23 were unable to participate for the following reasons: workload and annual leave restrictions; email address challenges; no response after follow-ups; travelled overseas; potential conflict of interest; and failure, without a reason to appear for the scheduled interview. A total of 17

participants took part in the study (42.5% response rate), including 12 males and five females. The majority were radiation/clinical oncologists ($n = 11$) with a smaller number of medical physicists ($n = 3$), radiation therapists ($n = 2$), and an administrator. Ten participants were working permanently in either Ethiopia, Egypt, Brazil, Kenya ($n = 2$), Jordan, India, Nepal, Peru, and Zambia. All remaining participants ($n = 7$) were permanently employed in four HICs (Australia [$n = 3$], Canada [$n = 2$], USA [$n = 1$], or Qatar [$n = 1$]) but had been involved in various initiatives to strengthen radiotherapy in multiple LMICs.

Interviews lasted an average of 35 min. Despite participants' diversity of experiences across LMICs, three major themes and 15 associated subthemes were identified as critical to establishing and sustaining high-quality radiotherapy services in LMICs (see Table 1). The major themes were: (1) committing to a vision of improving cancer care; (2) making it happen and sustaining a safe service; and (3) leveraging off radiotherapy to strengthen integrated cancer care.

4 | COMMITTING TO A VISION OF IMPROVING CANCER CARE

4.1 | Policy environment

There was unanimous agreement that committing to a cancer control vision, political stability and basic infrastructure like the quality supply of electricity were prerequisites to successful radiotherapy service establishment. A critical success factor was the political will to support establishing radiotherapy services with the capacity to meet the service demands of the population. Most participants perceived that a country's inability to commit and establish radiotherapy was linked to political impasses, periodic changes of political leadership, bureaucratic corruption, multiple competing political demands, and policy-makers' negative misperception about investing in radiotherapy:

There's a misperception that radiotherapy is expensive...and that comes from the fact that there is a barrier to entry associated with how much it costs to buy a linear accelerator...It's one of the reasons the GTFRC...analysis is very important (P5, RO, International).

4.2 | Advocacy

Participants described the availability of "vision champions" as essential to convincing decision makers that investing in cancer care was important. "Vision champions" were recognized as good negotiators and networkers, resilient, enthusiastic, and trustworthy individuals or groups, who provided leadership and advocacy for improving access to radiotherapy services. A public figure being diagnosed with cancer often provided the impetus for country's political leaders to suddenly commit to radiotherapy. These opportunities needed to be carefully managed to optimize the country's investment to achieve the best outcome for the entire population:

TABLE 1 Barriers and facilitators to establishing and sustaining radiotherapy services in LMICs, with sample comments

Themes	Subthemes	Barriers	Facilitators	Exemplar comments from participants
1. Committing to a vision of improving cancer care	Policy environment	- Political impasses. - Bureaucratic corruption. - Lack of political leadership continuity. - Competing political demands on scarce resources. - Policymakers' negative misperception about radiotherapy.	- Political stability. - Political decision to invest in basic infrastructure. - Strong political support.	"...with the support of the Ministry of Health...six centres and teaching hospitals were selected to start cancer care, including radiotherapy" (P10, CO, Local). "...the most challenging things are politics, our politicians...they change every three or four years depending on the country. So, it's very difficult to have continuity of investment" (P13, RO, Local).
	Advocacy	- Feelings of power less to influence decision. - Lack of a coordinated advocacy effort.	- Vision champion. - Useful window of opportunity.	"[You need] someone that has some sort of clout...that will listen to...a university professor, or physician, or a senior medical physicist, or even someone that works in the government already" (P4, MP, International). "I think that the coordination of different individuals and groups would be a really good thing...[and] the work we do should primarily be directed towards government" (P6, RT, International).
	Radiation safety	- Nonmember State of the IAEA. - Lack of legal and regulatory framework.	- Member State of IAEA. - Availability of a regulator. - Availability of legal and regulatory framework.	"There is the Ministry of Health and there is the Ministry of Science and Technology, which are responsible for controlling all the radiation services and the radiation sources in the country" (P10, CO, Local). "We had to work with whatever radiation safety body within the country...and generate licenses...[because]...they're going to have a radiation-producing machine" (P4, MP, International).
	Country-wide radiotherapy implementation plan	- Poor planning. - Lack of reliable epidemiological data.	- Availability of a costed cancer control plan. - Accurate epidemiological data at the institutional or LMIC-level. - Access to global cancer data (GLOBOCAN).	"...you need radiotherapy to be installed within a comprehensive national cancer control program. So, you need the cancers that are preventable being prevented. You need early detection so that the cases that are coming into radiotherapy are maximised... Then you're palliating the ones that can be palliated" (P15, RT, International). "The starting point is the demographics, which again may or may not be available in some countries...in many cases, the data were extrapolated, especially in Africa because there are so few countries with good cancer registries" (P3, RO, International).
	Identifying a funding model	- Lack of a comprehensive and reliable line-item budget. - Poor mobilization and allocation of financial resources.	- Diversified sources of funding—public, private, partnerships, and philanthropic investment. - Ability to develop a well-framed business case for investment in radiotherapy. - Ability to gain long-term financial commitment.	"I approached a bank for a loan and when the bank financed the loan, now we bought a property to build a centre that houses everything under one roof... they've [bank] been quite supportive in trying to make sure the facility is built... The process was first you have to give a business case and then they have to come and evaluate the feasibility of the plan." (P9, CO, Local). "...there is a little bit of a trend... where a company will come in with what they call a turn-key solution. So, they will come in [country] and they will build the building, put the equipment in, commission the equipment, get it ready to go, and in some cases put workforce in there for a period of time... Then they walk away... and... turn over to local people to run and operate" (P15, RT, International).

(Continues)

TABLE 1 (Continued)

Themes	Subthemes	Barriers	Facilitators	Exemplar comments from participants
1. Making it happen and sustaining a safe service	Building the facility and purchasing the right machinery	• Lack of local radiotherapy expertise. • Poor stakeholder engagement. • Lack of a competent project manager. • Lack of negotiating power of LMICs. • Lack of coordination and communication among relevant stakeholders. • Lack of synchronization of different activities.	• IAEA's technical cooperation programme. • Access to suitable land, with space for future expansion. • Ability to create a multidisciplinary implementation team. • Appointment of a responsible project manager. • Creation of a technical assistance plan. • Appropriate arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment. • Access to experienced contractors. • Engagement of expert volunteers.	"...we had a local architect who could collaborate and share the drawings with an international person to critique and give input" (P9, CO, Local). "...the medical physicists were not involved, right from the beginning...when the companies came to evaluate the status of the bunkers, they found some design problems" (P10, CO, Local).
	Building the radiotherapy workforce	• Absence of a suitably trained workforce. • Lack of sufficiently qualified teachers and mentors. • Lack of appropriate incentives. • High degree of brain drain after overseas education and training. • Lack of staff succession plan.	• Availability of a workforce development plan. • Timely arrangement to ensure staff education and training is undertaken in centers with patient population and equipment relevant to the needs of the LMIC. • Availability of innovative educational programmes such as Virtual University for Cancer Control and Africa Radiation Oncology Network. • Arrangement to establish a country-based accredited training programme. • Appropriate incentive strategies to attract and retain workforce.	"I always make it very clear that professionals at a minimum you need radiation oncologist, medical physicist and radiation therapist. It's a three-legged stool, if one of the legs do not work, the stool doesn't work. For at least those three professions, and then you can also put in oncology nursing and dietitian and so on" (P2, MP, International). "In one case...the facility was ready, the equipment was installed, but the trainees were not ready...and what happened during that time, rats and mice basically ate up the wiring" (P3, RO, International). "...the biggest challenge...of the educational program is the residency part, because the residency part is extended, you need experienced people, you need technology to be able to give proper residency training" (P2, MP, International).
	Gaining and maintaining financial stability	• Lack of financial resources to support service operation. • Financial hardship to patients and their families.	• Clear financial mechanism for operational sustainability.	"...there is government and private cooperation resources that have gone into setting up the facility...however, patients end up paying for their radiotherapy services" (P6, RT, International). "We have insurances paying for them, but majority...do not really have medical insurance" (P9, CO, Local).
	Regular maintenance	• Lack of a long-term service contract. • Poor spare parts supply and distribution. • Expensive spare parts. • Lack of qualified engineers.	• Build a critical mass of equipment. • A well-negotiated service contract to minimize downtime. • Favorable trade and border legislation that eliminates procedural barriers to medical goods across the border.	According to our [service] agreement, the uptime of our machines must exceed 95%...For example, one linear accelerator stops working for some or other reason; we make a call out, the engineer is supposed to be on-site, according to the agreement, within one hour (P17, MP, Local). "...all these machines are coded in American dollars...our currency is not very good right now...So, they say, 'Okay, we don't want the machine anymore because you're giving the machine you are not giving money for the next five years to maintain the machine' (P13, RO, Local).

(Continues)

TABLE 1 (Continued)

Themes	Subthemes	Barriers	Facilitators	Exemplar comments from participants
	Building research culture and infrastructure	Lack of research capacity in radiotherapy.	- International and/or regional research collaborations. - Allocation of funds for research.	"Building research capacity is the only way...because being a researcher generates the data that then supports that it's worth it, to make more investment... People don't care about opinions, they care about statistics and evidence" (P14, CO, Local). "...they should really link with some very good regional and international cancer centres to learn" (P7, RO, Local).
	Good governance and management	Lack of clear roles and responsibilities.	- Availability of an inclusive governance and management board - Leadership that fosters continuous expansion.	"The cancer hospital is run by 9-member management committee... These board members are responsible for the development... and all the financial aspect... of the hospital... they have a certain time frame" (P14, Administrator, Local). "The machines will be sold, but there's not any kind of responsibility... to see it through to the end. It's just like, 'Okay we've sold it. That's it'." (P1, RO, International).
	Improving patient outcomes	- Lack of trust based on information and communication processes. - Lack of needed social support services. - Limited access to evidence-based clinical guidelines.	- Adoption of evidence-based practice. - Availability of social services for patients such as transport and accommodation assistance schemes. - Involvement of patients and their families. - Development of trust based on quality service.	"...with good service... we received the trust of the people... it's very important... they don't trust the government hospital; they don't trust other NGO hospitals. When they have money, they choose the private hospital" (P14, Administrator, Local). "We use guidelines and sit every year to review these guidelines. We put the guidelines under discussions... we agree on international guidelines, which is there in our system" (P7, RO, Local).
1. Leveraging off radiotherapy to strengthen integrated cancer care	Catalyzing comprehensive care and support service	- Inability to plan and priorities the integration sufficiently. - Expensive process for governments.	- Vision and milestones to develop a comprehensive cancer center. - Strong clinical and political leadership support. - Long-term financial commitment. - Development of strategic partnerships.	"They implemented radiotherapy in a fantastically staged fashion. So, stage one was to build that radiotherapy centre; stage two was to build extra buildings next door to create dedicated cancer wards. Stage three was to start their own training programmes and start to undertake cancer research... it's a clinician that led this implementation approach. He was very, very strategic... That really helped in terms of getting funding through, getting decisions taken, all of that high-level support" (P15, RT, International). "...it is very difficult because we are depending on government grants... For now, we have been depending on partners who are interested... I think the frame-work with development... is very large and it has very long-term funding. It's about achieving milestones, and we are kind of still working through that funding" (P16, CO, Local).
	A multidisciplinary approach to care	- Differences between professional perspectives. - Lack of understanding of the role of radiotherapy.	- Service providers motivated to provide patient-centered care. - Availability of a multidisciplinary cancer conference/operational policy. - Respectful collegial relationships. - Motivation to provide evidence-based and coordinated cancer treatment and care. - Commitment to regular attendance.	"...we work under one scientific umbrella without having this problem of junior or senior, or different school, British school or American, or local. We faced that problem in the past... with differences of views... but then we created our internal law here that no patient can be treated without having a decision by the multidisciplinary team" (P7, RO, Local). "Some departments are easier to collaborate with surgeons and others are not... For instance, in prostate, the patient should be offered radiation or surgery... the surgeons will treat the majority of the patient without even offering radiation... sometimes most of these surgeons they have no idea what radiation is, and they think, 'Okay, this is gonna burn the patient, I don't want them to have that... we are now trying to educate the surgeons... and also educate the patient' (P13, RO, Local).

(Continues)

TABLE 1 (Continued)

Themes	Subthemes	Barriers	Facilitators	Exemplar comments from participants
	Information and communication technologies (ICTs)	Inadequate training and assistance for users.	- Supportive technology and information access. - Electronic platform for training and multidisciplinary conference. - Adequate training for information technologists. - Access to the internet.	"We are connecting everybody digitally so that people can network, conference and move ahead... we do weekly Tumour Boards using the ECHO platform... specialists can connect with each other, present their cases and do things" (P11, RO, Local). "With information technology... we have a program available on the internet, which is educating regularly" (P12, RO, Local).

...[even when] there are no resources, a First lady gets breast cancer...and suddenly these resources appear...often these VIPs would travel to Europe or North America for treatment and then they would come back and say, "We want all the bells and whistles that we saw" (P3, RO, International).

4.3 | Radiation safety

Participants stressed that a critical first step was for a country to become a member of the IAEA, to develop country-wide radiation safety laws, including the establishment of a regulatory authority to ensure timely approval of the radiotherapy plan before the commencement of the facility construction:

...countries have to apply for membership in the IAEA...As part of membership, they may have to pay a modest fee...but then they are also required to have some legislation in place, for accountability of the radioactive materials (P3, RO, International).

4.4 | Country-wide cancer control policy with radiotherapy implementation plan

Participants described the importance of having a country-wide radiotherapy implementation plan. Having a costed country-wide cancer control policy with radiotherapy plan demonstrated the government's commitment to control cancer and theoretically address many of the barriers that participants identified namely, fragmented services and inadequate geographical coverage. Participants suggested a significant barrier to a comprehensive cancer control vision was the lack of reliable epidemiological data, essential to developing a country-wide radiotherapy plan. Epidemiological data were key to developing the investment case, determining the optimal location, and type of technology that would best serve the populations' needs:

...what we are doing is to prepare a roadmap as to which states should have equitable radiotherapy access. Because just stating that a country needs 40 radiotherapy or brachytherapy units without knowing where they are required, ends up that many are [established] in major cities (P11, RO, Local).

4.5 | Identifying a funding model

Participants identified a viable funding model as crucial to ensure a country was able to commit to construction, equipment set-up and maintenance, and workforce development. Participants described multiple funding models including public, private, public-private partnership, and charitable. Regardless of the model, long-term funding was critical to consider from the outset to ensure a sustainable radiotherapy service:

You have to start looking at the long-term plan. The cost-effectiveness reflects in sustainability (P4, MP, International).

Participants acknowledged that a well-framed business case that demonstrated radiotherapy benefit, financial, technical, and operational viability was essential to secure financial commitment. Some countries have adopted public-private partnership strategies where the private sector finance, design, build, operate, and maintain the facility for an agreed duration before handing over the responsibility to the public sector. Such partnerships were essential; however, it was a challenge when the country could not sustain the facility. While the private sector was recognized as an important source for financing a country's radiotherapy vision, it did not always promote equity of access and often created financial hardships for poor households without health insurance. Participants highlighted the vital role of charities and civil society organizations in mobilizing funds through community engagement, philanthropic and political commitments to addressing barriers, such as financial risks associated with accessing radiotherapy. However, arriving at a subsidy agreement required lobbying:

...government is subsidizing...diseases like cancer, kidney, and heart...\$1000 (US) per patient...we lobbied with the Ministry of Health...met the Prime Minister (P14, Administrator, Local).

5 | MAKING IT HAPPEN AND SUSTAINING A SAFE SERVICE

Establishing a radiotherapy service required project management inclusive of planning, construction, procurement, delivery, installation, commissioning, and workforce development. International support at

critical junctures, along with concurrent sustainability and contingency plans to manage unforeseen events which threatened the delivery of a fully function radiotherapy service on time and budget is also required.

5.1 | Building the facility and purchasing the right machinery

Securing a suitable location with space for future expansion and constructing the facility was recognized as a challenging task because of the need for resources. The right balance of local knowledge and international expertise helped to meet the safety and operational requirements. Without a competent project management team, there was a risk of the building process being derailed due to poor stakeholder engagement and suboptimal decision making, which contributed to cost overrun, project failure, and damaged reputations. Participants also highlighted the power differential between local teams and powerful, for-profit vendors. They described how vulnerable many LMICs were when negotiating with larger vendors and how this vulnerability was amplified if there was a lack of tendering and contract management experience within the team:

In [HICs], when we decide we want to buy a new machine, we have these experienced physicists who lead the negotiations...But you can imagine that, if the country has no experience in that, the vendors will be dictating (P1, RO, International).

Establishing collaborative relationships with centers of excellence and seeking technical assistance during the early planning stages was critical. Participants emphasized challenges in equipment licensing requirements at local regulatory levels, resulting in application processes being frustrating and hampered by long delays. Participants highlighted the important contribution that international experts, many of whom are volunteers. They ensured that radiotherapy machineries were correctly commissioned. Many of these experts, make a significant financial and/or time sacrifice to be based in an LMIC for anything up to a year:

... we've [international organisation] had...a medical physicist...there for 12 months...for their machine commissioning (P1, RO, International).

5.2 | Building the radiotherapy workforce

Building the radiotherapy workforce was essential to the operation and management of any radiotherapy facility. Providing radiotherapy safely required a core team of well-trained radiation oncologists, radiation therapists, and medical physicists. This team needs to be in place before the radiotherapy service can commence. The absence of a suitably trained workforce has led some LMICs to resort to inappropriately substituting other health professionals into radiotherapy roles they were not qualified to perform, jeopardizing patient and staff safety.

...often many departments are very keen to come on-board with new technology straight away when there has not necessarily [been any] training...the therapists are often...nurses...and told, "Okay, now you're the radiation therapist," with very little training (P1, RO, International).

Overseas training for staff was perceived as unavoidable when establishing radiotherapy for the first time; but was criticized as being expensive with different disease pattern and technology compared to types of equipment and cases of patients treated in most LMICs. Also, overseas training risked the loss of local talent due to better standard of living, attractive incentives, stable political environment, and access to advanced technology in HICs. As the length of workforce preparedness was lengthy, participants highlighted the need for workforce development to occur before installation of the equipment to prevent redundancy.

Creative approaches to workforce development were required, including a range of local and international solutions that addressed barriers, like insufficient qualified teachers and lack of mentors. They mentioned initiatives such as: e-learning platforms like Virtual University for Cancer Control, Africa Radiation Oncology Network and Chartrounds; and "train-the-trainers" initiatives by Radiating Hope and Royal Australian and New Zealand College of Radiologists (RANZCR):

Since the last one year or two through a partnership with American Society [of Radiation Oncology] International Outreach Program, Chartrounds, is available to us...It's a digital conferencing with weekly at least 30 to 40 radiation oncologists join in to promote education and training (P11, RO, Local).

Availability of appropriate incentive systems, which included financial and nonfinancial incentives, was described as crucial in attracting and retaining radiotherapy workforce.

5.3 | Gaining and maintaining financial stability

After the initial investment in establishing the radiotherapy facility, gaining and maintaining financial stability was crucial for operational sustainability. Participants described out-of-pocket payments, prepaid payment plans, social security funds, sustained donor pipeline, public taxes, government revenues and subsidies as payment models adopted to generate funds to sustain facility operations:

...we open our hospitals to investors 24 hours a day. So, investors may come and have a tour in the hospital. We show them how we treat our patients...that encouraged the people to donate (P8, RO, Local).

5.4 | Regular maintenance

During contract negotiations, it was essential to include an equipment maintenance clause to ensure equipment was serviced regularly, and parts could be readily sourced to minimize downtime. Expensive spare

parts, lack of dedicated funding, poor spare parts supply and distribution, as well as lack of qualified engineers were identified as major barriers to maintaining radiotherapy services. Establishing innovative infrastructure maintenance and replacement policies and building a critical mass of equipment from the same vendor were recommended to address most of the named maintenance challenges:

What typically happens is every country does its own thing and buys whatever they like...What I would recommend is if there was a cluster of countries...they all go with the same equipment vendor...so that you can have an engineer based in one of those countries that can swing around (P15, RT, International).

5.5 | Building research culture and infrastructure

Producing quality data about service performance and improvement was identified as key to further funding commitments from investors. Radiotherapy was, thus, best recognized as a valuable contribution to cancer control when there was a capability to finance long-term investment in collaborative research to produce innovative solutions:

...we have active groups in medical oncology and active groups in radiotherapy. We are investigating the ways of making better medicine with cheaper expenses (P12, RO, Local).

5.6 | Good governance and management

Critical to the successful provision of the broad range of clinical and nonclinical services was good governance and management team. Having an inclusive governance and management structure ensured there was a good representation when making decisions to provide quality care.

Participants suggested that to be sustainable, it was critical for the facility management team to have a high degree of accountability, transparency, and a culture of continuous expansion:

...is a charity hospital...but...we are...continuously expanding...there are two linear accelerators...And we started with 120 beds, but now 303 (P8, RO, Local).

5.7 | Improving patient outcomes

An important consideration identified was how the facility sustains patient flows in an ever-growing competitive environment. Creating a reputable brand by having a high-quality infrastructure, adopting evidence-based practices and engaging patients were facilitators that impacted patients' outcomes; hence, were crucial in gaining patients and donors' trust, loyalty, and commitment. A further success factor was ensuring that social support systems for patients addressed both medical and nonmedical costs when accessing radiotherapy:

It's about the extra small things that they [patients] want...when they [patients] are lodging at the hospital,

meals are provided, three meals a day for free (P16, CO, Local).

6 | LEVERAGING OFF RADIO THERAPY TO STRENGTHEN INTEGRATED CANCER CARE

Establishing a radiotherapy service was suggested to be the foundation for developing integrated cancer services inclusive of a comprehensive care strategy, multidisciplinary approach, and information technologies to improve outcomes.

6.1 | Catalyzing comprehensive care and support service

Achievement of a radiotherapy facility can play a central role in catalyzing the development of comprehensive cancer infrastructure to address all necessary aspects of cancer control. A stepwise approach with achievable roadmaps was vital:

It [radiotherapy] certainly can be a driver if you like to bring cancer services together...you do have to build custom infrastructure and facilities...it tends to be, well rather than just build a radiotherapy centre, let's build a cancer centre...I have seen it work like that (P15, RT, International).

6.2 | Multidisciplinary approach to care

Participants emphasized the importance of building a multidisciplinary team with a patient-centered comprehensive care goal. Two models of a multidisciplinary approach to care were identified, which included: multidisciplinary clinics; and multidisciplinary cancer conferences to discuss the diagnostic and treatment of cancer patients' care. They suggested that collegial relationships, commitment to regular meetings, and availability of operational policies or protocols to standardize care were essential characteristics of a successful multidisciplinary team approach. However, some participants perceived differences between professional perspectives and lack of understanding of the role of radiotherapy created challenges committing to a multidisciplinary path:

Surgeons want to be the owners of the patient, so they want to...bill, they want to get more treatments to the patient, and will only refer to radiation in most of the cases when they cannot do anything else (P13, RO, Local).

6.3 | Information and communication technologies (ICTs)

Participants described how the availability of ICTs contributed to effective integration. The primary objective of implementing ICTs was to improve patient outcomes. Another critical objective was to promote the training of the radiotherapy workforce. Participants explained ICTs as electronic enabling tools for processing and disseminating clinical and nonclinical information to aid effectiveness:

...we have a hospital information system in which this referral is [documented]...every person in the hospital has access to this hospital information system (PB, RO, Local).

7 | DISCUSSION

This qualitative study provides novel exploratory insights into the barriers and facilitators to establishing and sustaining radiotherapy services in LMICs. It demonstrates that radiotherapy establishment is a complex large-scale initiative dependent on multiple critical success factors. These factors relate to a country's ability to demonstrate commitment toward radiotherapy; capacity to translate commitment into results; and capability to leverage off radiotherapy to strengthen integrated care.

There is an implication that integrating a costed radiotherapy development plan in a country-wide cancer control programme promotes collaborative and coordinated investment actions. Accurate local data are required for effective planning.²⁰ However, the situation remains that most LMICs lack epidemiological data to inform cancer control actions.¹ Developing high-quality radiotherapy requires investment in initiatives to strengthen research capacity.^{4,21} Through partnerships at the international level, the Global Initiative for Cancer Registry Development is empowering countries to advance information systems for cancer control.²² While trends in cancer incidence and mortality are needed, it is essential to develop a cancer survival database to inform service design and continuous improvement.

Funding arrangements are critical to establish and sustain radiotherapy services. However, state-of-the-art radiotherapy facilities are established out of a sense of social service with limited focus on sustainability. Achieving universal health coverage for radiotherapy requires diverse funding sources, including public, private, philanthropic, and partnership investments. Irrespective of the source, political commitment is integral to facilitate resource mobilization and allocation. Governments must recognize radiotherapy as a critical driver of economic growth.⁴ A well-managed facility can function for almost 40 years and the equipment can operate for about 20 years.²³ However, equipment becomes less efficient after 10 years and spare parts are harder to obtain and more costly. Having strategic maintenance and replacement policy is critical to minimize downtime while prioritizing equipment that needs to be replaced.⁷

Consistent with several studies in health and nonhealth, the findings indicate that effective project management is crucial for achieving radiotherapy establishment.^{10,24–26} Appointing a project manager with skills to coordinate activities is integral. In situations where a country is establishing radiotherapy for the first time and the right expertise is unavailable, recruiting external expertise is essential.⁸ The principles of stakeholder participation are also important to promote codesign and ownership.

Sustaining radiotherapy facilities in LMICs is achievable but requires a capable workforce. Tailored in-country education and training initiatives are emerging and have proven successful.^{27–29} Multiple opportunities for regional training, mentoring and network

building have been created. They include Africa Radiation Oncology Network (AFRONET) and Virtual University for Cancer Control by IAEA and "train-the-trainers" approach by Radiating Hope, RANZCR, and Medical Physics for World Benefit.^{3,30–32} Links with radiotherapy centers in HICs are vital in improving technical support.² The findings confirmed those of previous evidence that depending on overseas training is unsustainable.^{30,33}

This study highlights the importance of readiness assessment prior to establishing a radiotherapy service. To achieve an objective assessment of a country's readiness often proves to be challenging due to the lack of indicators. Providing a relevant tool for readiness assessment is imperative. The factors identified in this study provide a promising starting point. It will also be important to strengthen the various innovation programmes for researching and developing innovative technologies to address most of the identified radiotherapy challenges. Thus, LMICs have opportunities to invest in potentially "leapfrog" radiotherapy technologies. Like mobile diagnostic units, mobile radiotherapy service delivery models can make a significant impact on access to radiotherapy service in LMICs. There is value in sharing lessons learned from radiotherapy implementation in a global context.

8 | STRENGTHS AND LIMITATIONS

The strengths of this study are: participants had varied experiences in establishing, strengthening, sustaining, and/or delivering radiotherapy across LMICs; we involved the views multiple disciplines within radiotherapy, thus, increasing our confidence in the data. The sample size of this study was enough to capture and understand broad themes related to radiotherapy service implementation, which will enable us to develop item indicators for a future survey with a large sample size. A few limitations are important to mention. First, participants were required to recount their experiences and may have created recall bias. Additionally, while telephone interviews enabled us to gain insight into the various implementation barriers and facilitators, we were unable to take account of facial expression and body language.

9 | CONCLUSION

This study identified several barriers and facilitators to establishing high-quality sustainable radiotherapy services in LMICs. We identified examples of successful radiotherapy services in LMICs that were largely achieved through strong political support, advocacy activities of vision champions, diversified sources of funding, strategic partnerships, costed cancer control plan, adoption of evidence-based practice, prepared workforce, technical assistance from IAEA and other expert volunteers, well-negotiated service contract and international and/or regional research collaborations. Assessing the level of readiness to establish and sustain a radiotherapy service is highly recommended. Future research is recommended to develop a readiness assessment tool for radiotherapy services implementation at LMICs.

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AVAILABILITY OF DATA AND MATERIALS

De-identified datasets analyzed in the current study are available from the corresponding author on reasonable request.

AUTHORS CONTRIBUTIONS

All authors contributed to manuscript writing, editing and final approval, including table design. Donkor, Lockett, Aranda, and Phillips conceived the study. Donkor, Aranda, and Phillips facilitated recruitment. Donkor, Lockett, and Phillips led the data collection. Data analysis was performed by Donkor with consensus discussions with all authors. Vanderpuye assisted with interpretation of the findings. All authors reviewed the draft manuscript and provided approval to the final manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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Appendix K: Barriers and facilitators to establishing safe and sustainable radiotherapy services in LMICs, with participants' comments

Themes	Sub-themes	Barriers	Facilitators	Exemplar comments from participants
1. Committing to a vision of improving cancer care	Policy environment	- Political impasses. - Bureaucratic corruption. - Lack of political leadership continuity. - Competing political demands on scarce resources. - Policymakers' negative misperception about radiotherapy.	- Political stability. - Political decision to invest in basic infrastructure. - Strong political support.	<i>"...the most challenging things are politics, our politicians...they change every three or four years depending on the country. So, it's very difficult to have continuity of investment" (P13, RO, Local).</i>
	Advocacy	- Feelings of powerless to influence decision - Lack of a coordinated advocacy effort.	- Vision champion. - Useful window of opportunity.	<i>"I think that the coordination of different individuals and groups would be a really good thing...[and] the work we do should primarily be directed towards government" (P6, RT, International).</i>
	Radiation safety	- Non-member State of the IAEA. - Lack of legal and regulatory framework.	- Member State of IAEA. - Availability of a regulator. - Availability of legal and regulatory framework.	<i>"There is the Ministry of Health and there is the Ministry of Science and Technology, which are responsible for controlling all the radiation services and the radiation sources in the country" (P10, CO, Local).</i> <i>"We had to work with whatever radiation safety body within the country...and generate licenses...[because]...they're going to have a radiation-producing machine" (P4, MP, International).</i>
	Country-wide radiotherapy implementation plan	- Poor planning. - Lack of reliable epidemiological data.	- Availability of a costed cancer control plan. - Accurate epidemiological data at the institutional or LMIC-level.	<i>"The starting point is the demographics, which again may or may not be available in some countries...in many cases, the data were extrapolated, especially in Africa because there are so few countries with good cancer registries" (P3, RO, International).</i>

2. Making it happen and sustaining a safe service	Identifying a funding model	• Lack of a comprehensive and reliable line-item budget. • Poor mobilisation and allocation of financial resources.	• Access to global cancer data (GLOBOCAN). • Diversified sources of funding – public, private, partnerships and philanthropic investment. • Ability to develop a well-framed business case for investment in radiotherapy. • Ability to gain long-term financial commitment.	<i>"I approached a bank for a loan and when the bank financed the loan, now we bought a property to build a centre that houses everything under one roof ... they've [bank] been quite supportive in trying to make sure the facility is built... The process was first you have to give a business case and then they have to come and evaluate the feasibility of the plan." (P9, CO, Local).</i>
	Building the facility and purchasing the right machinery	• Lack of local radiotherapy expertise. • Poor stakeholder engagement. • Lack of a competent project manager. • Lack of negotiating power of LMICs. • Lack of coordination and communication among relevant stakeholders. • Lack of synchronisation of different activities.	• IAEA's technical cooperation programme. • Access to suitable land, with space for future expansion. • Ability to create a multidisciplinary implementation team. • Appointment of a responsible project manager. • Creation of a technical assistance plan. • Appropriate arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment. • Access to experienced contractors. • Engagement of expert volunteers.	<i>"...we had a local architect who could collaborate and share the drawings with an international person to critique and give input" (P9, CO, Local).</i> <i>"...the medical physicists were not involved, right from the beginning...when the companies came to evaluate the status of the bunkers, they found some design problems" (P10, CO, Local).</i>
	Building the radiotherapy workforce	• Absence of a suitably trained workforce. • Lack of sufficiently qualified teachers and mentors.	• Availability of a workforce development plan. • Timely arrangement to ensure staff education and training is undertaken in centres with	<i>"I always make it very clear that professionals at a minimum you need radiation oncologist, medical physicist and radiation therapist. It's a three-legged stool, if one of the legs do not work, the stool doesn't work."</i>

	• Lack of appropriate incentives. • High degree of brain drain after overseas education and training. • Lack of staff succession plan.	patient population and equipment relevant to the needs of the LMIC. • Availability of innovative educational programmes such as Virtual University for Cancer Control and Africa Radiation Oncology Network. • Arrangement to establish a country-based accredited training programme. • Appropriate incentive strategies to attract and retain workforce.	<i>For at least those three professions, and then you can also put in oncology nursing and dietitian and so on" (P2, MP, International).</i> <i>"...the biggest challenge...of the educational program is the residency part, because the residency part is extended, you need experienced people, you need technology to be able to give proper residency training" (P2, MP, International).</i>
Gaining and maintaining financial stability	• Lack of financial resources to support service operation. • Financial hardship to patients and their families.	• Clear financial mechanism for operational sustainability.	<i>"...there is government and private cooperation resources that have gone into setting up the facility...however, patients end up paying for their radiotherapy services" (P6, RT, International)</i> <i>"We have insurances paying for them, but majority...do not really have medical insurance" (P9, CO, Local).</i>
Regular maintenance	• Lack of a long-term service contract. • Poor spare parts supply and distribution. • Expensive spare parts • Lack of qualified engineers.	• Build a critical mass of equipment. • A well-negotiated service contract to minimise downtime. • Favourable trade and border legislation that eliminates procedural barriers to medical goods across the border.	<i>According to our [service] agreement, the uptime of our machines must exceed 95%....For example, one linear accelerator stops working for some or other reason; we make a call out, the engineer is supposed to be on-site, according to the agreement, within one hour (P17, MP, Local).</i> <i>"...all these machines are coded in American dollars...our currency is not very good right now...So, they say, 'Okay, we don't want the machine anymore because you're giving the machine you are not giving money for the next five years to maintain the machine' (P13, RO, Local).</i>
Building research culture and infrastructure	• Lack of research capacity in radiotherapy.	• International and/or regional research collaborations.	<i>"Building research capacity is the only way...because being a researcher generates the data that then supports that it's worth it, to</i>

		Allocation of funds for research.	<i>make more investment... People don't care about opinions, they care about statistics and evidence" (P16, CO, Local).</i> <i>"...they should really link with some very good regional and international cancer centres to learn" (P7, RO, Local).</i>
	Good governance and management	- Lack of clear roles and responsibilities. - Availability of an inclusive governance and management board - Leadership that fosters continuous expansion.	<i>"The cancer hospital is run by 9-member management committee...These board members are responsible for the development... and all the financial aspect...of the hospital... they have a certain time frame" (P14, Administrator, Local).</i> <i>"The machines will be sold, but there's not any kind of responsibility...to see it through to the end. It's just like, "Okay. we've sold it. That's it". (P1, RO, International).</i>
	Improving patient outcomes	- Lack of trust based on information and communication processes. - Lack of needed social support services. - Limited access to evidence-based clinical guidelines. - Adoption of evidence-based practice. - Availability of social services for patients, such as transport and accommodation assistance schemes. - Involvement of patients and their families. - Development of trust based on quality service.	<i>"...with good service...we received the trust of the people...it's very important...they don't trust the government hospital; they don't trust other NGO hospitals. When they have money, they choose the private hospital" (P14, Administrator, Local).</i> <i>"We use guidelines and sit every year to review these guidelines. We put the guidelines under discussions... we agree on international guidelines, which is there in our system" (P7, RO, Local).</i>
3. Leveraging off radiotherapy to strengthen integrated cancer care	Catalysing comprehensive care and support service	- Inability to plan and prioritise the integration sufficiently. - Expensive process for governments. - Vision and milestones to develop a comprehensive cancer centre. - Strong clinical and political leadership support. - Long-term financial commitment. - Development of strategic partnerships.	<i>"They implemented radiotherapy in a fantastically staged fashion. So, stage one was to build that radiotherapy centre; stage two was to build extra buildings next door to create dedicated cancer wards. Stage three was to start their own training programmes and start to undertake cancer research...it's a clinician that led this implementation approach. He was very, very strategic... That really helped in terms of getting funding through, getting decisions taken, all of that high-level support" (P15, RT, International).</i>

			“...it is very difficult because we are depending on government grants...For now, we have been depending on partners who are interested...I think the frame-work with development...is very large and it has very long-term funding. It's about achieving milestones, and we are kind of still working through that funding” (P16, CO, Local).
A multidisciplinary approach to care	• Differences between professional perspectives. • Lack of understanding of the role of radiotherapy.	• Service providers motivated to provide patient-centred care. • Availability of a multidisciplinary cancer conference operational policy. • Respectful collegial relationships. • Motivation to provide evidence-based and coordinated cancer treatment and care. • Commitment to regular attendance.	“...we work under one scientific umbrella without having this problem of junior or senior, or different school, British school or American, or local. We faced that problem in the past...with differences of views... but then we created our internal law here that no patient can be treated without having a decision by the multidisciplinary team” (P7, RO, Local). “Some departments are easier to collaborate with surgeons and others are not...For instance, in prostate, the patient should be offered radiation or surgery...the surgeons will treat the majority of the patient without even offering radiation...sometimes most of these surgeons they have no idea what radiation is, and they think, "Okay, this is gonna burn the patient, I don't want them to have that...we are now trying to educate the surgeons... and also educate the patient” (P13, RO, Local).
Information and communication technologies (ICTs)	• Inadequate training and assistance for users.	• Supportive technology and information access. • Electronic platform for training and multidisciplinary conference. • Adequate training for information technologists. • Access to the internet.	“We are connecting everybody digitally so that people can network, conference and move ahead... we do weekly Tumour Boards using the ECHO platform...specialists can connect with each other, present their cases and do things” (P11, RO, Local). “With information technology... we have a program available on the internet, which is educating regularly” (P12, RO, Local).

Appendix L: Publication and Permission to Re-Use Content – Participant Validation Process (Study Two [Part B])

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Original paper

Developing a readiness self-assessment tool for low- and middle-income countries establishing new radiotherapy services: A participant validation study

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ABSTRACT

Purpose: Assessing low- and middle-income countries' (LMICs) readiness to establish new radiotherapy services is an important but empirically understudied concept. The purpose of this study is to develop and confirm a core set of readiness requirements and criteria that can be used to gauge LMICs' preparedness to establish radiotherapy services.

Methods: Based on a systematic review and semi-structured expert interviews, a pool of requirements and criteria were generated. To confirm or disconfirm these items, we adopted a synthesised member checking process, also known as participant validation. A purposive sampling strategy was used to recruit radiotherapy experts. Items were sent via email. Each item was reviewed by participants. Qualitative comments were analysed thematically.

Findings: Seven of the 17 experts who participated in an earlier semi-structured interview contributed to this participant validation study. The final version of the readiness self-assessment tool for LMICs establishing new radiotherapy services contains 37 requirements mapped into four readiness domains, grouped under the following categories: commitment; cooperation; capacity; and catalyst. Among 23 criteria for commitment domain, participants reviewed 22 as relevant for inclusion. The cooperation requirements considered important, included: "strategic planning team", "stakeholder involvement" and a "technical assistance plan". Capacity requirements, which were endorsed included: "responsible project manager", "availability of radiotherapy expertise", and "training for initial core staff". Participants' feedbacks supported the inclusion of all the requirements and criteria related to catalyst.

Conclusion: The readiness self-assessment tool is a promising planning and evaluation tool for use by stakeholders interested in expanding access to radiotherapy services in LMICs.

1. Introduction

Achieving universal radiotherapy access is a global health concern. Health and cancer organisations and agencies such as International Atomic Energy Agency (IAEA), World Health Organisation (WHO) and Union for International Cancer Control (UICC) are working to ensure that radiotherapy services are more accessible and available to everyone who needs them [1–3]. Improving access to radiotherapy services has largely developed in response to the increasing cancer burden in low- and middle-income countries (LMICs), accompanied by

awareness and advocacy strategies. Globally, governments are being encouraged to commit resources to establish high-quality sustainable radiotherapy services to address the evolving cancer treatment and palliative care needs of their populations [4].

Radiotherapy is clinically indicated for more than half of all cancer cases, as either a treatment to cure, palliate and/or improve patients' quality of life. Improving cancer outcomes of working age people increases labour force participation [5]. This indicates that, when successfully established, a radiotherapy service provides both health and economic benefits [5,6]. Similar to other health projects, when poorly

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implemented, the establishment of sub-optimal radiotherapy services can have negative impacts on cancer patients' outcomes, wastes scarce financial resources, damages industry integrity, and contributes to a population's mistrust [7,8]. Success of a new radiotherapy service is dependent upon being established on time, within budget and meeting all the various quality and safety requirements. Many new radiotherapy services fail because of poor stakeholder engagement, fatal construction flaw(s), procuring unsuitable equipment and not integrating maintenance into the project plan [9]. In addition to these barriers, establishing new radiotherapy services in LMICs have been hindered by challenges such as the lack of political support, absence of radiotherapy expertise, ineffective project management, lack of radiation safety infrastructure and weak contract management [10,11].

Assessing LMICs' readiness to establish radiotherapy services has become increasingly essential to governments, planners, coordinators and regulators so that they can better support investment decisions and planning priorities. Readiness refers to the state of being prepared to undertake the implementation of any development project [12]. A readiness assessment can be conducted systematically using qualitative or quantitative indicators, or both [13]. While quantitative readiness indicators can provide numerical snapshots of the preparedness, qualitative readiness indicators offer insightful information necessary for understanding and defining the requirements for evidence-based monitoring and evaluation [13,14]. Both qualitative and quantitative readiness indicators are widely used as planning, self-assessment or managerial tools to identify progress, opportunities and barriers aimed at informed decision-making, accountability, learning, designing and selecting appropriate strategies to maximise achievement of results [15,16].

Establishing a new radiotherapy service is a complex multiple stage process [4]. However, the literature has not yet provided a validated readiness assessment tool that objectively assess an LMIC's preparedness to establish a radiotherapy service. The aim of this study is to develop and confirm a core set of readiness requirements and criteria that can be used to gauge LMICs preparedness to establish radiotherapy services.

2. Methods and analysis

2.1. Study design

A participant validation study was undertaken using a synthesised member checking qualitative technique [17]. A participant validation was used to improve the trustworthiness of the content of the readiness self-assessment tool for LMICs establishing new radiotherapy services. The study design, data collection, analysis and reporting were conducted in accordance with well-recognised approaches for developing and validating tools [17–19]. This study is part of a larger project approved by the Human Research Ethics Committee, University of Technology Sydney, and all participants had previously given a verbal informed consent to participate. Data collection for this phase of the project took place between July 2019 and October 2019.

2.2. Participants and setting

Expertise in radiotherapy establishment and sustainability is dependent on training, practical service delivery and/or experience with initiatives to improve access to radiotherapy at global, regional and/or national levels with organisations such as Union for International Cancer Control, International Atomic Energy Agency, Radiating Hope and International Cancer Expert Corps.

Radiotherapy experts including 11 radiation oncologists, three medical physicists, two radiation therapists and an administrator were eligible to participate in this study. These radiotherapy experts had elaborated the successful establishment of high-quality sustainable radiotherapy services in LMICs through a series of semi-structured

interviews [20]. Ten of the radiotherapy experts were working permanently in LMICs, including Kenya, Ethiopia, Egypt, Brazil, Jordan, India, Nepal, Peru and Zambia. The remaining experts were permanently employed in four high-income countries, including Australia, Canada, USA and Qatar, but had been actively involved in establishing and/or improving radiotherapy services in LMICs.

2.3. Recruitment of participants

A purposive domain-based sampling strategy was adopted to recruit participants with a wide range of experience who could give insights that, collectively, would reduce the risk of construct under-representation within the readiness self-assessment tool for LMICs establishing new radiotherapy services. Recruitment was via direct email contact from one of the researchers (AD).

2.4. Data collection and procedure

The participant validation process is recognised as an essential technique for enabling researchers to refine their data interpretations and enhance credibility [17]. The sections below detail the processes undertaken in completing the participant validation process and included: generating an initial list of item requirements; confirming item requirements; and refining item requirements.

2.4.1. Step one: initial generation of the readiness items

The first step of the participant validation process was to identify critical domains that can be used to describe readiness to establish new radiotherapy services in LMICs. Our starting point was establishing high-quality sustainable radiotherapy services is a complex process, which requires interconnected activities. To corroborate this view, we conducted a systematic review and a series of semi-structured interviews, identifying the facilitators and barriers to establishing high-quality sustainable radiotherapy services in LMICs [9,20]. The findings revealed that radiotherapy establishment readiness domains, can be grouped under the following four categories: commitment/cooperation; capacity; and catalyst. We defined each readiness domain for establishing high-quality sustainable radiotherapy services as follows:

- Domain 1: 'Commitment'**, defined as an LMIC's willingness to put in place the necessary political, policy, funding and regulatory requirements to enable a new radiotherapy service to be established;
- Domain 2: 'Cooperation'**, defined as the effective involvement of relevant international, national and local stakeholders in the planning, commissioning and operationalisation of a new radiotherapy service;
- Domain 3: 'Capacity'**, defined as an LMIC's ability to translate commitment and cooperation to achieve sustainable results through effective and efficient management of the implementation process, a prepared workforce, maintenance, governance and information technology; and
- Domain 4: 'Catalyst'**, defined as the potential for an LMIC to leverage off a new radiotherapy service to develop an integrated cancer care service.

Item requirements and associated criteria are used to assess a defined readiness domain [21]. Based on the conceptual definition of each readiness domain, we generated a preliminary list of suitable item requirements and criteria of readiness based on our systematic review and the semi-structured interviews [9,20]. We generated 42 item requirements and 71 criteria that addressed the four readiness domains. The item requirements underwent iterative editing and consensus, review and proofreading processes by the research team (AD, TL, SA and JP) to clarify, and proof requirements for coverage and overlap prior to being sent to the radiotherapy experts for confirmation.

2.4.2. Step two: experts' confirmation of the readiness items

This step aimed to have radiotherapy experts select, cross-check and confirm whether the requirements generated were appropriate and relevant to qualitatively assess readiness to establish a new radiotherapy service. Radiotherapy experts confirming their agreement with the generated requirements helped establish the requirements' relevance and representativeness of the topic being studied [22–24]. Consensus was defined as the collective judgement and opinion of radiotherapy experts on the readiness item requirements and their associated criteria. Consensus implied general agreement, though not necessarily unanimity [25]. The process of reaching consensus also meant that each radiotherapy expert was given the equal opportunity to correct errors, challenge or confirm accurate interpretations and influence the final decision on readiness item requirements and criteria [26,27]. Therefore, to achieve consensus, item requirements and criteria were framed in practically agreeable terms.

The literature is varied regarding the number of experts required to review and confirm generated items that should form the content of a tool [28]. Sample size decisions are mostly based on the length and complexity of the tool [28]. Nevertheless, some studies have recommended a range between six to 20 experts to help generate more information about the tool [28,29]. As described under the participant and setting section, 17 eligible radiotherapy experts received the survey document and information sheet with the conceptual definition of each readiness domain, the associated item requirements and criteria. For the tasks, radiotherapy experts were asked if they agree with the readiness items by addressing the following statements:

1. If you think any of the item requirements already listed under the readiness domains should be removed, please place "R" as "Remove" in the inclusion column;
2. If you think any of the item requirements already listed under the readiness domains should be included but needs to be revised or modified in some way, please "M" as "Modify" in the inclusion column;
3. If you think any of the item requirements already listed under the readiness domains should be included without changes, please place "A" as "Accept" in the inclusion column.

In addition, radiotherapy experts had an option for a 'no idea'. To evaluate the comprehensiveness of each readiness domain, experts were also asked to recommend other requirements that might have been omitted from the list, items that should be deleted because they are not consistent with the readiness domain and/or items that should be combined. This approach is consistent with the literature on tool development [30,31].

A flexible response strategy was adopted that offered participants the option to complete the validation process over the telephone or submit the completed document electronically. Each radiotherapy expert was given two weeks to complete the survey. A follow-up email reminder prompting potential participants about the deadline to complete the survey was sent. If there was no response, it was considered a decline to participate. Participants completing and submitting the survey was considered as consent to cover all aspects of participation and use of the collected data.

2.5. Data analysis

The data from the participant validation process generated words of text, which were analysed qualitatively; hence, median score and interquartile range were not calculated [17]. Qualitative comments from participants were imported into NVivo-12 for management, organisation and coding. Replicable and valid inferences from the texts were made through content analysis. Texts that were of interest to the analysis were systematically distinguished and comments from participants were read and re-read at several levels of word, sentence, paragraphs

and whole to gain an understanding of the meaning. The researcher remained open to understanding the new, deleted or combined requirements recommended by the participants without a pre-specified framework. Coded texts were grouped into categories reflecting readiness requirements. Areas of convergence and discrepancy among participants were identified through constant comparison, a qualitative data-analytic procedure whereby each finding and interpretation is compared with existing findings emerging from the data analysis [32]. Regular feedback meetings were held with TI to share comments from participants, discuss and validate the refined requirements and criteria. Feedback is a common iterative consensus approach for supporting validity or trustworthiness by reflecting on the data [33].

3. Findings

3.1. Description of participants

A total of 17 invitations were distributed via email, with seven completions. Ten experts were unable to participate for the following reasons: no response after follow-ups ($n = 7$) or other pressing work priorities ($n = 3$), leaving a response rate of 41.2%. Majority of the participants ($n = 4$) who completed the survey were females. Only one participant completed the survey via a telephone conversation, while the remaining completed and submitted it through email. Three participants were working permanently in Australia. The other participants were working in Jordan ($n = 1$), India ($n = 1$), Ethiopia ($n = 1$) and Zambia ($n = 1$). Five of the participants were radiation/clinical oncologists and two were radiation therapists.

3.2. Requirements and criteria identification and confirmation

Participants examined requirements and criteria for each of the four readiness domains, categorised as: commitment; cooperation; capacity; and catalyst. Table 1 shows the item requirements that were sent to participants and their feedback. Majority of the feedback from participants were consistent, with minimal annotation.

3.2.1. Requirements and criteria for commitment

Among 23 criteria for commitment requirements, participants confirmed 22 as relevant for inclusion. Most participants indicated that two requirements "political window of opportunity" and "radiotherapy lobbying" convey advocacy messages to gain political commitment. Hence, they were merged into a single requirement "opportunities for advocacy". Even though there was less agreement regarding the relevance of "stable political environment" as a requirement, it was included because a stable political environment was needed to attract long-term investment and gain the necessary technical support from the international community to develop radiotherapy.

Participants favoured the requirement "access to basic infrastructure", confirming the important role of water, electricity and roads infrastructure for establishing a new radiotherapy service. The first and third criteria for the requirement "access to basic infrastructure" were reworded to include the phrases "has a plan to construct sewerage systems at the radiotherapy facility" and "with adequate onsite or nearby parking for staff, patients and their families, and enable goods to be delivered to the facility" respectively. Criteria for the four requirements "identified require information", "cancer control policy", "policy coherence" and "public statements by political leaders" were confirmed as important for inclusion because they concern avenues to engage policy to improve radiotherapy services. The requirement "identified require information" was reworded as "access to information" for clarity. Participants unanimously confirmed the need to identify an appropriate funding model, with a long-term budgetary commitment to establish and maintain the radiotherapy service. Based on participants' comments, the word "maintenance" was introduced into the third criterion for the requirement "suitable funding model", which was

Table 1
Original items, with global radiotherapy expert feedback.

Domain	Requirements	Criteria	P1	P2	P3	P4	P5	P6	P7	Comments
Commitment	Stable political environment	The LMGC has no ongoing civil war or political violence.	R	A	M	A	A	A	A	"May in our radiotherapy projects are directly or indirectly related to unstable political situation. I would be happy if this is not excluded" – P6
	Quality of basic infrastructure service	The LMGC has government structures and processes defined by rules or laws to support policy-making and service planning. The LMGC has consistent supply of water and electricity over long periods.	R	A	M	A	A	A	A	"Include average too. I have been in some radiation therapy centers in LMGCs where there are no outlets" – P3
	Political window of opportunity	The LMGC has a plan for backing power to keep the radiotherapy facility functioning. The LMGC has good road and transport system to the radiotherapy facility sites, with parking on-site. An opportunity to advance for the development of radiotherapy services is presented by high-profile public figures being diagnosed with cancer who has had to seek therapy outside the LMGC.	A	A	A	A	A	A	A	"I had the roads and transport are important, parking could be nearby and not necessarily on-site" – P2
Radiotherapy	Radiotherapy lobbying	Civil society organizations and influential individuals are building political momentum in establishing radiotherapy services by collaboratively campaigning, advocating and/or lobbying.	A	A	A	A	A	A	A	
	Policy coherence	The Ministry responsible for Health has documents/policies that publicly acknowledge the need to strengthen cancer care, including radiotherapy services(s).	A	A	A	A	A	A	A	
	Cancer control policy	The LMGC has a Ministry approved comprehensive cancer control strategy that details the vision, values, direction, budget allocation and timelines to develop or enhance radiotherapy services.	M	M	A	A	A	A	M	
Public statements by political leaders	Public statements by political leaders	Political leaders have made strong public statements supporting and endorsing the need to effectively and efficiently implement the components of the cancer control policies as outlined in the cancer control plan.	M	M	A	A	A	A	A	"It may not be possible to implement all elements of a national cancer control plan in one go...[but]...radiotherapy is effective if introduced within a comprehensive cancer control plan" – P1
	Identified negative information	The LMGC has access to reliable and accurate epidemiological data at the institutional or country level, which can be used to determine the country's cancer profile as well as determine optimal equipment and facility sizing plans.	A	A	M	A	A	A	M	"Maybe say they need commit to creating a cancer registry" – P3
	Stable funding model	The LMGC has developed a detailed project plan for the development of the new radiotherapy services that identifies timelines, clear roles and responsibilities for all relevant stakeholders and project milestones. The LMGC and/or an external agency has identified a secure source(s) of ongoing funding for the development of radiotherapy services. The LMGC, with a statement from an external agency has a prepared budget document to help make case for long-term public, private, philanthropic or partnership financial commitments for the project. The government, private partner and/or philanthropic organizations have agreed to financially support efforts in the LMGC to develop or enhance access to radiotherapy services.	A	A	A	A	A	A	A	"Ensure that necessary replacement and maintenance cost are included" – P6
Governance	Committed to Universal Health Coverage	The LMGC has identified and secured funding support for a scale-up implementation approach and ongoing operational sustainability of the services.	A	A	A	A	M	A	A	
	Membership status with the International Atomic Energy Agency (IAEA)	The LMGC has taken steps to start achieving universal health coverage by establishing a national health insurance program. The LMGC has taken steps to start achieving universal health coverage by providing government subsidies for selected health services. The LMGC signed the 20th October 1958 Statute within 90 days after it was opened for signature and became a member of IAEA.	A	M	A	A	A	A	M	"These two criteria on UHC could be combined" – P2
	Legal and regulatory framework	The LMGC has deposited an instrument of acceptance of the Statute to become a member of IAEA.	A	A	A	A	A	A	A	

(Continued on next page)

Table 1 (continued)

Domain	Requirements	Criteria	P1	P2	P3	P4	P5	P6	P7	Comment
Cooperation	Independent country-level regulator	The LMCC has a legal and regulatory framework to safeguard the use of ionising radiation. The LMCC has created an independent regulator to inspect, authorise and enforce the legislation and regulations. The LMCC has created an independent regulator to ensure compliance with international standards of radiation safety, security and protection.	A	M	A	A	A	A	A	
	Inclusive planning team	The LMCC has formed a planning team with the right mix of skills, knowledge and experience to coordinate with relevant stakeholders and oversee the planning of the new radiotherapy service, such as carrying out the needs assessment and determining the feasibility of the radiotherapy project.	A	M	A	M	A	A	A	"Maybe use the term 'strategic planning' to there is no confusion between it and radiation therapy planning" – P3
	Technical working group	The LMCC has created a functional technical working group to support the planning team as a coordination and information-sharing group responsible for defining technical requirements and recommendations.	A	M	A	A	A	A	A	"Is not how this is explicitly separate from the inclusive planning team" – P2
	Identify and engage relevant stakeholders	The LMCC has performed a stakeholder analysis to define, engage and gain better understanding of the range of institutions, organisations, professional bodies and individuals who have interest in and can influence the radiotherapy project.	A	A	A	R	A	A	A	
	Technical assistance plan	The LMCC has engaged international technical assistance programmes and invited the designated Agency or organisations to aid where further support is needed while avoiding duplication and conflicting advice.	A	A	A	A	A	A	A	
Capacity	Stakeholder involvement	The international agency or organisation providing technical assistance has involved relevant in-country stakeholders in broader consultations in defining specific needs, strategic plan and document submission early buy-in of the planning process and local ownership of the new radiotherapy service.	A	A	A	A	A	A	A	
	Stakeholder consensus-building	The Agency working together with the LMCC have achieved consensus on the priority areas, such as equipment by circulating their plan and providing opportunity for stakeholders to express their view on the radiotherapy plan.	M	M	A	A	A	A	A	
	Trust relationships	The LMCC has a good track record based on the previous history of working collaboratively with international development partners.	R	R	A	A	R	R	R	
	Multi-disciplinary implementation team	The LMCC has formed a multi-disciplinary implementation team to manage the building of the new radiotherapy facility once the radiotherapy plan has been approved at the ministerial level.	A	A	M	A	A	A	A	
	Responsible project manager	The LMCC has appointed an experienced project manager with technical and relevant contextual knowledge to help develop timelines and coordinate the implementation activities such as construction, equipment procurement, installation and timely training of staff.	A	A	A	A	A	A	A	
Availability of radiotherapy expertise	Availability of radiotherapy expertise	The LMCC has relevant local radiotherapy expertise available or when unavailable locally the LMCC has recruited external experts such as clinicians (radiation oncologist and medical physicist), architects, building contractors and engineers to design, construct and commission the new radiotherapy facility in accordance with all regulatory requirements.	A	A	A	A	A	A	A	
	Access to a suitable land	The LMCC has secured a suitable land, with space for future expansion, address environmental issues such as flood and earthquakes.	M	M	M	A	A	A	A	
	Construction of the building	The LMCC has identified and secured the services of experienced contractors to complete the building and handover it for housing the radiotherapy equipment in a timely manner.	M	A	A	A	A	A	A	"Add engineering board statement to redesign natural disaster and construction engineering risks in the statement" – P3
	Equipment purchase, delivery and set-up	The LMCC has negotiated with a vendor for optimal equipment purchase, timely delivery and installation, with the necessary planning systems, standards in machine and data entry devices for monitoring dose equivalent.	A	A	M	A	A	A	A	"Add medical specific patient information management software and/or accuracy equivalent to the statement" – P3
			A	A	A	A	A	A	A	(continued on next page)

Table 1 (continued)

Domain	Reported item	Criteria	F1	F2	F3	F4	F5	F6	F7	Comment
Training for initial core staff	The LMCC has made arrangements for maintaining and licensing of the new radiotherapy service prior to the start of patient treatment. The LMCC has selected a dedicated team of health professionals and adequate arrangements made to train them to form the core workforce – radiation oncologists, radiation therapists and medical physicists. The LMCC has requested for assistance from the LMA to support placement of the candidates in suitable training sites while noting the importance of training on relevant equipment and relevant disease profiles. The LMCC has a plan to ensure the training commenced immediately the radiotherapy project is approved to reduce delays or ongoing services of equipment. The LMCC has appropriately identified and trained other supporting staff such as cancer care nurses, social workers and case managers or coordinators. The LMCC has a long-term strategic plan for building local training capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff attrition, leave, retirement, change in jobs and brain drain due to overseas benefits. The LMCC has knowledge of staffing needs and plan to participate in regional steering programmes to address staff knowledge and skill gaps. The LMCC has made arrangements for suitable financial and non-financial incentive systems, including appropriate relations to motivate and retain staff. The LMCC has a commercial service agreement for the purchased equipment to enable timely engineering support to minimise downtime. The LMCC has arranged to select and train a team of in-house engineers as part of the governance plan. The LMCC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts and replacement of obsolete equipment.	A	M	A	A	A	A	A	A	"Add details and occupational therapy services to the statement" – F3
		Other supporting staff	A	M	A	A	M	A	A	
		Staff recruitment plan	A	A	M	A	A	A	A	
		Incentive systems	A	A	M	A	A	A	A	
		Service contract	R	M	A	M	A	A	A	
Spare parts	The LMCC has a commercial service agreement for the purchased equipment to enable timely engineering support to minimise downtime. The LMCC has arranged to select and train a team of in-house engineers as part of the governance plan. The LMCC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts and replacement of obsolete equipment.	A	A	A	A	A	A	A	A	"In the longer term it might mean forming local engineers or if critical need is an issue, then a sub-regional network, such as West African engineers' group who service multiple countries" – F1
		Service contract	A	A	A	A	A	A	A	
		Staff recruitment plan	A	A	A	A	A	A	A	
		Incentive systems	A	A	M	A	A	A	A	
		Service contract	R	M	A	M	A	A	A	
Governance and management structure	The LMCC has made arrangements for maintaining and licensing of the new radiotherapy service prior to the start of patient treatment. The LMCC has selected a dedicated team of health professionals and adequate arrangements made to train them to form the core workforce – radiation oncologists, radiation therapists and medical physicists. The LMCC has requested for assistance from the LMA to support placement of the candidates in suitable training sites while noting the importance of training on relevant equipment and relevant disease profiles. The LMCC has a plan to ensure the training commenced immediately the radiotherapy project is approved to reduce delays or ongoing services of equipment. The LMCC has appropriately identified and trained other supporting staff such as cancer care nurses, social workers and case managers or coordinators. The LMCC has a long-term strategic plan for building local training capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff attrition, leave, retirement, change in jobs and brain drain due to overseas benefits. The LMCC has knowledge of staffing needs and plan to participate in regional steering programmes to address staff knowledge and skill gaps. The LMCC has made arrangements for suitable financial and non-financial incentive systems, including appropriate relations to motivate and retain staff. The LMCC has a commercial service agreement for the purchased equipment to enable timely engineering support to minimise downtime. The LMCC has arranged to select and train a team of in-house engineers as part of the governance plan. The LMCC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts and replacement of obsolete equipment.	A	M	A	A	A	A	A	A	"The LMCC has made arrangements for maintaining and licensing of the new radiotherapy service prior to the start of patient treatment. The LMCC has selected a dedicated team of health professionals and adequate arrangements made to train them to form the core workforce – radiation oncologists, radiation therapists and medical physicists. The LMCC has requested for assistance from the LMA to support placement of the candidates in suitable training sites while noting the importance of training on relevant equipment and relevant disease profiles. The LMCC has a plan to ensure the training commenced immediately the radiotherapy project is approved to reduce delays or ongoing services of equipment. The LMCC has appropriately identified and trained other supporting staff such as cancer care nurses, social workers and case managers or coordinators. The LMCC has a long-term strategic plan for building local training capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff attrition, leave, retirement, change in jobs and brain drain due to overseas benefits. The LMCC has knowledge of staffing needs and plan to participate in regional steering programmes to address staff knowledge and skill gaps. The LMCC has made arrangements for suitable financial and non-financial incentive systems, including appropriate relations to motivate and retain staff. The LMCC has a commercial service agreement for the purchased equipment to enable timely engineering support to minimise downtime. The LMCC has arranged to select and train a team of in-house engineers as part of the governance plan. The LMCC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts. The LMCC has made arrangements to ensure a team of in-house engineers is in place to support the improvement of care, including availability of spare parts and replacement of obsolete equipment."

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Table 1 (continued)

Domain	Population	Canada	P1	P2	P3	P4	P5	P6	P7	Comment
Cancer	Encourage cancer control/reform	The LMCC has adequately trained users in all levels to use the information technology.	A	R	A	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to persuade relevant stakeholders to think differently about cancer care.	A	R	M	A	A	A	A	"This may be too broad" – P3
		The LMCC has plans to use the new radiotherapy service to promote comprehensive service and optimize cancer prevention, diagnosis, treatment and palliative care outcomes.	A	A	M	A	A	A	A	"As the new service overriders and under the role of screening / early detection service will become more important" – P1
		The LMCC has plans to use the new radiotherapy service to aid sensitive policy-makers and health authorities to the growing burden of cancer and the importance of integrated cancer control strategies for managing it.	A	A	A	A	A	A	A	
Promote coordinated care	Promote coordinated care	The LMCC has plans to use the new radiotherapy service to upgrade information systems to improve coordination of care across providers, facilities and settings.	A	R	A	A	A	A	A	"Don't let me know, hard to cover all these aspects when resources are limited" – P2
		The LMCC has plans to use the new radiotherapy service to develop patient referral pathways and registries to increase innovation across specialists.	A	A	A	M	A	A	A	
		The LMCC has plans to use the new radiotherapy service to develop more coordination to support patients as they navigate the cancer care settings.	A	R	A	M	A	A	A	
		The LMCC has plans to use the new radiotherapy service to advocate for the promotion and implementation of multidisciplinary team management of cancer patients.	A	A	A	A	A	A	A	
Encourage patients and family-oriented care	Encourage patients and family-oriented care	The LMCC has plans to use the new radiotherapy service to develop and implement national cancer management guideline in collaboration with other stakeholders.	A	A	A	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to provide patients and families access to have information about cancer management and self-management support outside the healthcare setting through telephone or internet.	A	R	A	A	A	A	A	"This could be managed by the nurse co-ordinator" – P3
		The LMCC has plans to use the new radiotherapy service to develop education and self-building programmes for patients and families on the management of cancer.	A	R	A	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to anticipate and better meet the needs of cancer patients (example, transport, accommodation and food) in an incentive for low-income patients to adhere to treatment.	A	A	M	A	A	A	A	
Encourage better outcomes through research	Encourage better outcomes through research	The LMCC has plans to use the new radiotherapy service to develop wellness to support self-management strategies.	A	R	M	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to build stronger connections with the community to educate the community at large about the prevention of cancer.	A	R	A	A	A	A	A	"If this radiotherapy service should not be used for widespread cancer prevention programmes" – P3
		The LMCC has plans to use the new radiotherapy service to emphasize the importance of evidence-based cancer care.	A	R	M	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to support the conduct of local research to produce and disseminate the cost-effectiveness of innovative care and strategies.	A	A	A	A	A	A	A	
		The LMCC has plans to use the new radiotherapy service to establish international and regional collaboration where radiotherapy centres can exchange information, share expertise, policies and strategies to improve services.	A	A	A	A	A	A	A	

P = Participant; R = Remove; M = Modify; A = Accept; LMCC = Low- and middle-income country.

Table 2
Final items that ought to be used to assess LMDCs readiness to establish high-quality sustainable radiotherapy services.

Domain	Requirements	Criteria
Commitment	Stable political environment	1. The LMDC has no ongoing civil war or political violence to divert attention and resources away from cancer treatment and care 2. The LMDC has government structures and processes defined by rules or laws to provide important support for policy-making and development of public infrastructure 3. AC: The LMDC has no international sanction imposed on it, so as not to impede the work of international radiation oncology volunteers and experts
	Quality of basic infrastructure service	4. The LMDC has made arrangement to ensure supply of water, electricity to the radiotherapy service centre and has a plan to construct sewerage systems at the radiotherapy service centre 5. The LMDC has a plan for backup power to keep the radiotherapy service functioning 6. The LMDC has road and transport system to the radiotherapy service site, with a depot on site or nearby for staff, patients and their families, as well as enable goods to be delivered to the radiotherapy service centre
	Opportunities for advocacy	7. Champions have identified opportunities to advocate for the development of a radiotherapy service, such as a high-profile and influential public figure being diagnosed with cancer 8. Civil society organizations and influential individuals are building political interest in establishing radiotherapy service by collaboratively campaigning, advocating and/or lobbying 9. AC: The high-profile figure is a committed advocate and has the power to influence the decision to improve access to cancer treatment and care, including radiotherapy
	Policy coherence	10. The Ministry responsible for Health has documents/policies that publicly acknowledge the need to strengthen cancer care, including radiotherapy services(s)
	Cancer control policy	11. The LMDC has a Ministry approved comprehensive cancer control strategy that details the vision, values, directions, budget allocation and timelines to develop or enhance radiotherapy service 12. AC: The LMDC understands that radiotherapy is beneficial and effective when introduced within a national cancer control plan
	Public statements by political leaders	13. Political leaders have made strong public statements supporting and endorsing the need to align priorities and effectively implement the components as outlined in the cancer control plan in a prioritized manner
	Access to information	14. Preferably, the LMDC has access to reliable and accurate epidemiological data at the institutional or LMDC-level which can be used to determine the LMDC's cancer burden, thus enabling determination of optimal equipment, service timing and estimation of annual radiotherapy utilization rate (demand for services) 15. AC: The LMDC has access to global cancer data (GLOBOCAN) and has plans to establish a cancer registry through the support of International Agency for Research on Cancer (IARC) Global Initiative for Cancer Registry Development (GICRD)
	Sustainable funding model	16. The LMDC has developed a detailed project plan for the development of the new radiotherapy service that identifies timelines, clear roles and responsibilities for all relevant stakeholders and project milestones 17. The LMDC and/or an external agency has identified a secure source(s) of funding for the development and maintenance/operational sustainability of the radiotherapy service 18. The LMDC with assistance from an external agency has prepared a budget document to help make a case for long-term public, private, philanthropic or partnership financial commitments to develop or enhance access to radiotherapy service
	Commitment to Universal Health Coverage	19. AC: The LMDC has completed a health economic analysis to help make a business case 20. The LMDC has taken steps toward achieving universal health coverage by establishing a national health insurance program or government subsidies for cancer treatment and care to help protect patients and their families from financial hardships associated with accessing radiotherapy
	Membership status with the International Atomic Energy Agency (IAEA) Legal and regulatory framework Independent LMDC-level regulator	21. The LMDC signed the 26th October 1956 Statute within 90 days after it was opened for signature or has deposited an instrument of acceptance of the Statute to become a member of IAEA 22. The LMDC has a legal and regulatory framework to safeguard the use of ionizing radiation 23. The LMDC has created an independent regulator to: i) inspect, authorize actions and enforce the legislation and regulations; and ii) ensure compliance with international standards of radiation safety, security and protection
Cooperation	Strategic planning team	24. The LMDC has formed a strategic planning team with the right mix of skills, knowledge and experience to coordinate with relevant stakeholders and oversee in detail specific strategic planning of the new radiotherapy service, such as carrying out the needs assessment and determining the feasibility of the radiotherapy project 25. Within the strategic planning team, the LMDC has created a functional technical working group to support as an information-sharing group responsible for defining technical requirements and recommendations 26. AC: Members of the radiotherapy project team have enabled a smooth articulation between radiotherapy and any existing cancer services in the LMDC
	Stakeholder involvement	27. The LMDC has performed a stakeholder analysis to define, engage and gain a better understanding of the range of ministries, institutions, organizations, professional bodies and individuals who have interest in and can influence the radiotherapy project 28. The international agency or organization providing technical assistance has involved relevant in-LMDC stakeholders in broader consultations in defining specific needs, strategic plan and directions to ensure early buy-in of the planning process and local ownership of the new radiotherapy service 29. The Agency working together with the LMDC have achieved consensus on the priority areas, such as equipment by undertaking due diligence, circulating draft plan and providing an opportunity for stakeholders to express their views on the radiotherapy plan
	Technical assistance plan	30. The LMDC has mapped international technical assistance programmes and invited the designated Agency or organizations to aid where further support is needed while avoiding duplications and conflicting advice 31. AC: The extent and mechanisms for the technical assistance have been clearly defined by the LMDC and the international agency or organization

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Table 2 (continued)

Domain	Requirements	Criteria
Capacity	Multidisciplinary implementation team	32. The LMIC has formed a multidisciplinary implementation team that is responsible for the day-to-day management of the building of the new radiotherapy service once the radiotherapy plan has been approved at the ministerial level.
	Responsible project manager	33. The LMIC has appointed an experienced project manager with technical and relevant contextual knowledge to help develop timelines and coordinate the implementation activities such as construction, equipment procurement, installation and timely training of staff.
	Availability of radiotherapy expertise	34. The LMIC has relevant local radiotherapy expertise available or when unavailable locally the LMIC has recruited external experts such as clinicians (radiation oncologist and medical physicist), architects, building construction and engineers to design, construct and commission the new radiotherapy service in accordance with all regulatory requirements.
	Access to suitable land	35. The LMIC has secured suitable site for the radiotherapy service.
	Construction of the building	36. The LMIC has successfully conducted environmental and engineering hazard assessments to mitigate natural disaster and engineering risks.
	Equipment purchase, delivery and set-up	37. The LMIC has identified and secured the services of experienced contractors to complete the building and bunker(s) for housing the radiotherapy equipment according to specifications and project timelines.
		38. The LMIC has contracted a vendor for optimal equipment purchase (radiotherapy and brachytherapy with applications), timely delivery and installation, as well as oncology-specific patient information management software and other ancillary equipment, such as planning systems, simulation machine, dosimetry devices and immobilisation devices.
		39. The LMIC has made arrangements for commissioning and licensing of the new radiotherapy service prior to the start of patient treatment.
	Training for initial core staff	40. The LMIC has identified candidates for radiotherapy leadership positions and arrangements have been made to train all staff to form the core workforce – radiation oncologists, radiation therapists and medical physicists.
		41. The LMIC has made arrangement for onsite vendor training and/or participation in an international mentorship programme for specific clinical education and training.
	Other supporting staff	42. The LMIC has a plan to ensure that immediate staff education and training are undertaken in continuity with patient populations, equipment and training programmes relevant to the needs of the LMIC.
		43. The LMIC has appropriately identified and trained other supporting staff such as cancer care nurses, social workers, dietitians, occupational therapists, information technologists and case managers or coordinators.
	Staff retention plan	44. As part of a scale-up implementation strategy, the LMIC has a long-term strategic plan for building in LMIC radiotherapy specific academic and clinical education capacity to ensure the continuous development of radiotherapy workforce locally while addressing concerns about expected staff annual leave, retirement, change in jobs and brain drain due to overseas benefits.
Catalyst	Incentive systems	45. The LMIC has knowledge of staffing needs and plans to articulate with regional professional networks and participate in regional e-learning programmes for continuous professional development to address staff knowledge and skill gaps.
	Service contract	46. The LMIC has made a management for suitable financial and non-financial incentive packages for staff, including appropriate salaries to motivate and retain staff.
	Spare parts	47. The LMIC has a contractual service agreement for the purchased equipment to enable timely engineering support to minimise downtime.
		48. The LMIC has arranged to select and train a team of in-house engineers as part of the procurement plan.
		49. The LMIC has carefully negotiated with the vendor with a strong radiotherapy presence in the region to support the improvement of care, including the availability of spare parts and training of engineers.
		50. The LMIC has made a management to generate funds through service charges or government revenues to support the radiotherapy service maintenance over the long-term period, including purchasing of spare and repair parts and replacement of obsolete equipment.
	Governance and management structure	51. AG: The LMIC has created favourable trade and border legislation that encourages compliance and eliminate procedural barriers to medical goods across the border.
		52. The LMIC has created an inclusive governance and management board plan for the new radiotherapy service to ensure there is participation in higher-level decision-making, strategic direction, financial and clinical governance, such as being accountable to patients and their families.
	Treatment guidelines, protocols and standard operating procedures	53. AG: The LMIC has created a plan to ensure that the radiotherapy service articulates with other cancer services, such as diagnostics, medical oncology, and palliative care.
	Other essential health services	54. The LMIC has made arrangement to develop radiotherapy guidelines, protocols, standard operating procedures or has a plan to adopt international standards to guide the best practice of radiotherapy.
		55. The new radiotherapy service has other essential health services available, such as radiological (computerised tomography [CT] scan, Magnetic Resonance Imaging [MRI] and ultrasound scan), laboratory and nuclear medicine on-site or the LMIC has taken steps towards outsourcing such services from nearby health services.
	Social support services	56. The LMIC and/or civil society organisations have programmes in place to provide social support services for patients, such as transport, accommodation assistance scheme, dietary support and information services.
	Generate, compile, analyse and communicate health data	57. The LMIC has a basic health information system in place to collect clinical and non-clinical information to formulate that meet the dissemination and communication needs of care providers, managers, patients and families to aid decision-making.
		58. The LMIC has well-trained information technologists to implement appropriate safeguards to protect patient data confidentiality.
	Encourage cancer control reform	59. The LMIC has identified that the new radiotherapy service will help the LMIC meet its cancer control goals and ready to act on an opportunity to improve equity in cancer control.
		60. The LMIC has plans to use the new radiotherapy service as a window of opportunity to promote and mobilise resources to develop a comprehensive service and optimise all aspect of cancer control (prevention, diagnosis, treatment and palliative care).

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Table 2 (continued).

Domain	Requirements	Criteria
Promote coordinated care		61. The LMIC has plans to use the new radiotherapy service to and sensitize policy-makers and health authorities to the growing burden of cancer and the importance of integrated cancer control strategies for managing it.
		62. If possible, the LMIC has plans to use the new radiotherapy service to upgrade information systems to improve coordination of care across providers, services and settings.
Promote a multidisciplinary approach to care		63. The LMIC has plans to use the new radiotherapy and/or other services to develop patient referral pathways and registries to increase transition across specialists.
		64. Using nurse coordinators, the LMIC has plans to support patients as they navigate the complex cancer treatment and care pathway.
Strengthen patient- and family-centred care		65. The LMIC has plans to use the new radiotherapy service to advocate for the promotion and implementation of multidisciplinary team management of cancer patients.
		66. As a window of opportunity, the LMIC has plans to use the new radiotherapy service to facilitate the development and implementation of national cancer management guidelines in collaboration with other specialists.
Encourage better outcomes through research		67. The LMIC has plans to use the new radiotherapy service to provide patients and families access to basic information about cancer management and self-management support outside the healthcare setting through nurse coordinators or the internet.
		68. The LMIC has plans to use the new radiotherapy service to develop educational and skill-building programmes for patients and families on the management of cancer.
		69. Through collaboration, the LMIC has plans to use the radiotherapy service to better meet the needs of cancer patients (e.g. transport, accommodation and food) as an incentive for low-income patients to adhere to treatment.
		70. The LMIC has plans to use the new radiotherapy service to develop written and online patient education materials to support self-management strategies, which could be adopted by other LMICs.
		71. The LMIC has plans to use the new radiotherapy service to build a strong connection with community organisations to promote awareness and use of radiotherapy.
		72. The LMIC has plans to use the new radiotherapy service to emphasise the importance of evidence-based cancer care and the need to implement cancer registry through partnerships.
		73. The LMIC has plans to use the new radiotherapy service to support the conduct of local research to produce and demonstrate the cost-effectiveness of innovative care and strategies.
		74. The LMIC has plans to use the new radiotherapy service to establish international and regional collaborations where radiotherapy centres can exchange information, share expertise, policies and strategies to improve services.

AC = Additional criteria that emerged from experts' comments; Bold texts indicate major modifications to a requirement or criterion based on experts' comments and LMIC = Low- and middle-income country.

changed to read "the LMIC and/or an external agency has identified a secure source(s) of funding for the development and maintenance/operational sustainability of the radiotherapy service". The requirement "commitment to universal health coverage" was considered critical in ensuring that patients and their families are protected from the financial burden associated with accessing a radiotherapy service. Three of the top-endorsed requirements - "membership status with IAEA", "legal and regulatory framework" and "independent LMIC-level regulator" - reflect the value attached to radiation protection and safety. There was general feedback to merge criteria within the radiation safety requirements.

3.2.2. Requirements and criteria for cooperation

Criteria for six of the seven original requirements linked to cooperation were confirmed relevant for inclusion. The requirement "trust relationship" was dropped as it was considered less relevant by most participants. Two requirements "identify and engage relevant stakeholders" and "stakeholder consensus-building" were merged and incorporated into the requirement "stakeholder involvement". Efforts to make information available and keep stakeholders informed about the radiotherapy development activities were critical to ensuring national and international stakeholders participate in the planning process. "Technical assistance plan" as a requirement was considered necessary to achieve coherent collaboration and teamwork. Several participants suggested the combination of two requirements "inclusive planning team" and "technical working group" into a single requirement "strategic planning team" relating to coordination and overseeing the strategic planning of the new radiotherapy service.

3.2.3. Requirements and criteria for capacity

Participants confirmed criteria for 16 of the 17 original

requirements related to capacity as relevant for inclusion. In relation to effective management capabilities to implement a radiotherapy service, participants confirmed the importance of creating a multidisciplinary implementation team, appointing a responsible project manager, securing suitable land and allocating resources for building construction process, equipment purchase, delivery and installation. Four requirements "training for initial core staff", "training other supporting staff", "staff succession plan" and "incentive systems" were focused on addressing local radiotherapy workforce development. In spite of the requirement "incentive systems" not reaching sufficient consensus, we included it because poor incentive was considered a major contributing factor to the brain drain in most LMICs. Minor typographical errors were corrected to improve readability. For example, "access to a suitable land" was reworded "access to suitable land". Participants confirmed criteria for two requirements "governance and management structure" and "treatment guidelines, protocols and standard operating procedures" as critical to ensuring a high-quality of transparency and accountability. The implementation of simple and basic information systems was required to generate, compile, analyse and communicate health data. The second criterion for the requirement "generate, compile, analyse and communicate health data" was reworded to "the LMIC has well-trained information technologists to implement appropriate safeguards to protect patient data confidentiality". Criteria for two requirements "service contract" and "spare parts" were endorsed, reflecting the importance of regular maintenance and repair.

3.2.4. Requirements and criteria for catalyst

There were relatively high endorsement of all five original requirements and 16 criteria related to catalyst domain. Participants confirmed that radiotherapy services can facilitate the harmonisation and integration of cancer service delivery by addressing three key

requirements: “encouraging cancer control reform”; “promoting co-ordinated care”; and “promoting a multidisciplinary approach to care”. Also, participants confirmed the importance of orienting cancer care around patients and their families to address their broader needs. Most of the participants’ comments and keywords to improve catalyst domain were indicative of the need to clarify, insert missing information and elaborate criteria for the following requirements: “encourage cancer control reform”; “strengthen patient- and family-centred care”; and “encourage better outcomes through research”. For instance, to accommodate the views of participants, we inserted the missing information “the need to implement cancer registry through partnerships” into the first criterion for the requirement “encourage better outcomes through research”. Similarly, the second criterion for the requirement “promote a multidisciplinary approach to care” was slightly reworded to clarify that establishing a radiotherapy service can be used “as a window of opportunity” for the development and implementation of oncology clinical practice guidelines.

3.3. Evaluating the comprehensiveness of requirements and criteria

Comprehensiveness was assessed based on the need for additional requirements and/or criteria required to make each readiness domain complete. None of the participants suggested an additional requirement. However, new criteria were developed by applying sentences that participants used in describing requirements. Table 2 presents the refined items and the nine additional criteria that emerged from participants’ comments, which included: five for commitment; two for co-operation; and two for capacity. For example, a new criterion “the LMIC acknowledges that unrestrictive customs and border laws are required for timely importation of spare parts” was created under the requirement “spare parts”.

4. Discussion

This study proposes a set of 37 requirements and 74 criteria that ought to be considered for inclusion in a readiness self-assessment tool for LMICs establishing new radiotherapy services. While there is no definite formula to promote the establishment of a successful radiotherapy service, the proposed readiness self-assessment tool is expected to generate processes that ought to be considered when LMICs are planning to establish new radiotherapy services. The readiness self-assessment tool for LMICs establishing new radiotherapy services focuses on providing practical guidance through four key readiness domains, grouped under the following categories: ‘commitment, cooperation, capacity and catalyst’. Each readiness domain has a broad range of qualitative theme-based requirements that were confirmed by expert participants.

Commitment is a fundamental requisite for success in establishing a new radiotherapy service. Advocating for increased political commitment to improve access to quality and equitable radiotherapy services can be complex. Advocacy can bring about positive results when constructively applied in these circumstances. Exploiting windows of opportunity is vital to building and/or maintaining political support for funding, policy and institutional commitments to establish a radiotherapy service. Funding a radiotherapy project in any LMIC can be challenging, so often, the suggestion is to secure a long-term budgetary commitment from diverse sources. It is critical to take into consideration public, private and/or philanthropic financial commitments in support of the radiotherapy project [9]. An LMIC demonstrating institutional commitment, such as availability of legal and regulatory frameworks and an independent regulator to ensure radiation safety, protection, security and quality through collaboration with IAEA is a critical factor for establishing a radiotherapy service.

In establishing a new radiotherapy service, it is essential to consider stakeholder cooperation leading to a collective action. There are three cooperation requirements of importance for LMICs to consider:

strategic planning team; stakeholder involvement and technical assistance plan. A strategic planning team that recognises and appreciates the advantage of understanding the LMIC’s current capacity helps align activities and available resources. It is imperative to place greater emphasis on identifying and involving relevant stakeholders to enrich the radiotherapy service development planning effort.

A successful radiotherapy service development involves careful consideration of the LMIC’s capacity, as constraints on capacity exert a negative impact on radiotherapy services in LMICs [11]. The confirmed capacity requirements to ensure successful radiotherapy development address implementation resources and activities, workforce development, regular maintenance, leadership, other essential and complementary services and information systems. The implementation plan should articulate equipment and personnel requirements, taking into consideration the cancer incidence and mortality profile. LMICs preparing to establish radiotherapy services should consider incentive systems and policies to reduce brain drain and develop local expertise.

LMICs must take advantage of radiotherapy services to improve access to integrated service and optimise all aspect of cancer control, including palliative care. Therefore, requirements of catalyst help to address the need for harmonisation of cancer care, the orientation of care around patients and their families and building research capacity. This study is part of a larger learning process, which has successfully highlighted relevant requirements and criteria. However, there are still gaps that require further field research to refine the understanding of the requirements and criteria and the conditions under which they are predictive and informative. The findings of this study could be used as a guide to help LMICs obtain objective information to address challenges related to establishing a new radiotherapy service by making well-informed decisions and aligning budgets. The findings are not meant to be used as a checklist or substitute in-LMIC expert advice. Rather, we intend the tool be used to engage effectively in a range of collaborative discussions with diverse stakeholders to ensure a sustainable and cost-effective project.

5. Strengths and limitations

The strengths of this study include allowing a broader end-user engagement and participation (experience of both international and local experts) in generating and confirming requirements. This ensures that the assessment tool meets usability and practical needs of LMICs. The inclusive validation process allowed for the generation of new ideas and alternative explanations for a more comprehensive set of requirements and criteria. However, these items should be field-tested in a larger representative sample. The sample size was limited by the arduousness of participation given the large number of requirements and complexity of tasks.

6. Conclusion

Establishing a new radiotherapy service is a complex task and unplanned efforts can be expensive and futile. A readiness assessment is a step often omitted when establishing radiotherapy services in most LMICs. Investing a day or two stakeholders consultative workshop guided by the readiness self-assessment tool may guide decisions on resource allocations to achieve radiotherapy service implementation and sustainability goals.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Availability of data and materials

Anonymised datasets analysed in the current study are available from the corresponding author on reasonable request.

Authors contributions

All authors contributed to manuscript writing, editing and final approval, including table design. AD, TL, SA and JP conceived the study. AD facilitated recruitment and data collection. Data analysis was performed by AD with consensus discussions with all authors. AD, TL, SA and JP performed iterative editing, review and proofreading of the requirements and criteria. VV assisted with interpretation of the findings. All authors reviewed the draft manuscript and provided approval to the final manuscript.

Consent for publication

Not applicable.

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