A Conceptual Measurement Model for eHealth Readiness: a Team Based Perspective

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Abstract

Despite the shift towards collaborative healthcare and the increase in the use of eHealth technologies, there does not currently exist a model for the measurement of eHealth readiness in interdisciplinary healthcare teams. This research aims to address this gap in the literature through the development of a three phase methodology incorporating qualitative and quantitative methods. We propose a conceptual measurement model consisting of operationalized themes affecting readiness across four factors: (i) Organizational Capabilities, (ii) Team Capabilities, (iii) Patient Capabilities, and (iv) Technology Capabilities. The creation of this model will allow for the measurement of the readiness of interdisciplinary healthcare teams to use eHealth technologies to improve patient outcomes.

Introduction

The increase in the use of information and communication technology (ICT) in the delivery and administration of healthcare services has long been implicated to varying degrees as the cause of long term increases in health care expenditure [1–3]. Health technology more broadly however has and continues to have transformative effects on the delivery and administration of healthcare services. These transformations have significant implications for the efficacy and efficiency of the delivery of healthcare services to patients with the aim of improving health outcomes. Continued expenditure on health technology is inevitable. However, the total return on this investment could be improved through the existence of greater efficiency and effectiveness in use of health technologies by clinicians and patients. As such, need emerges for the determination of the level of fit that exists between a healthcare environment, its participants, and its technology.

The focus of this paper is to provide insight into factors that need to be considered for measuring eHealth readiness for healthcare teams, and in the construction of a conceptual model for the measurement of readiness in interdisciplinary healthcare teams. While this research aims to achieve an overarching understanding of the factors, there is a particular focus on eHealth and its application to healthcare within the domain of traumatic brain injury (TBI) rehabilitation. We developed a three phase methodology consisting of a qualitative study and literature review to identify relevant themes, construct and model formation, and model validation. From this methodology emerged a conceptual model for the measurement of the readiness of interdisciplinary healthcare teams to use eHealth technologies in the course of patient care.

Identification of readiness factors

eHealth technology has the capability and potential to transform the delivery of health services to patients everywhere. As it currently stands, there exists no model for the measurement of the ability for interdisciplinary healthcare teams to use eHealth in the context of the whole healthcare environment to improve patient outcomes.

There is a broad base of literature covering specific areas of eHealth such as the effect of public engagement [4], factors affecting clinician acceptance of technology [5], factors affecting team performance [6,7], organizational aspects of change and readiness [8,9] and factors affecting ongoing intervention participation[10].

Physician acceptance and decision to adopt eHealth technology has been identified as significant in explaining physician responses to technology [5,11,12]. As such, the level of technological acceptance by physicians and their decisions to adopt eHealth technology in their practice for their clients will form part of the assessment of the level of eHealth potential. In a study of 408 Hong Kong physicians, seven factors were identified as having significance in explaining physician technology acceptance: attitude, subjective norms, perceived behavioral control, perceived usefulness, perceived ease of use, and behavioral intention [5]. In a study of 519 responses by physicians practicing in the province of Quebec, significant factors influencing perceived responsibility were: perceived consequences,

personal normative belief, and self-identify [11]. Additionally, modelling of 114 Taiwan-based clinicians acceptance of eHealth found three factors with high explanatory fit: technology support and training, compatibility, and intention to use [12]. Factors concerned with physician acceptance of eHealth technology are necessities for diffusion into clinical practice [11].

Where eHealth technology is used by the patient in a setting such as their home, the level of acceptance in its use is likewise a necessity for improved clinical outcomes. Where the patient rejects or is unable to use the technology, the clinical outcome improvement is unable to be achieved. Investigation of such factors governing the engagement of patients with eHealth technology were determined as being: characteristics of users, technological functionality and issues, characteristics of eHealth services, social aspects of use, and eHealth services in use [4,10,13].

Factors have also been identified relating to the organization itself that affect employee engagement and acceptance of change. Culture and incentivization have been identified as contributing to employees having greater acceptance of change [14]. Management support and resource availability are also identified as being factors in organizational adoption of health technologies [12,15,16].

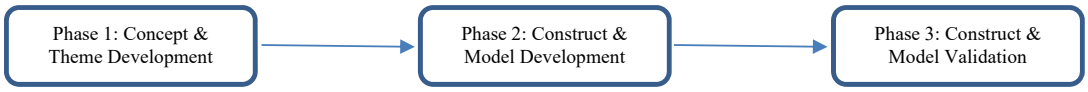
eHealth Literacy Toolkits

There are a number of frameworks which provide sets of measurement items and scales for constructs that have been established [17–20] to assess a participant's level of eHealth literacy. Norman and Skinner developed an eight item measure to ascertain the eHealth literacy of a participant (eHEALS) [17] with items concerned with patient competency with accessing health information found on the internet. The eight items are based on the six factor lily model [18] which establish the factors predicting eHealth literacy as: health literacy; traditional literacy and numeracy; computer literacy; information literacy; science literacy; and media literacy. Additionally there is the eHealth Literacy Assessment Toolkit (eHLA) [20] which similarly attempts to measure eHealth literacy and draws from the Norman and Skinner lily model and from the seven domains model [21].

The literature assessed is from a broad and fragmented body of work that has developed over the past five decades. The identification of relevant factors affecting the acceptance or the use of eHealth technologies is across three clusters: clinician, patient, and organization. Thus, these identified factors and clusters provide the basis for the formation of the conceptual model of eHealth readiness of interdisciplinary healthcare team.

Methodology

The goals of this research were to: (i) gain insight and an in-depth understanding of clinician perspectives of using eHealth technologies as an interdisciplinary team, (ii) develop a measurement model based on those experiences, and (iii) validate the model and propose a measure of readiness of an interdisciplinary healthcare team to use eHealth. The methodology combines qualitative and quantitative methods over three phases to devise a measurement. These phases are outlined below.



Phase 1 – Participant recruitment

Traumatic Brain Injury (TBI) was chosen as the domain due to the interdisciplinary nature of the work and the potential benefits that eHealth can bring to such work [22]. Thus, two focus groups and an interview were conducted to gain an understanding of the attitudes surrounding eHealth and interdisciplinary work within rehabilitation for people after TBI, with a third focus group used to confirm the content analyses of the two prior focus groups and interview [23]. Participants consisted of healthcare professionals working in TBI rehabilitation with two teams based in regional New South Wales (Australia), and the interview participant and the third team based in metropolitan New South Wales (Australia). Recruitment for all four studies was based upon the purposeful sampling technique [24].

Phase 1 – Focus group data collection

Four key questions were used to facilitate discussion between participants based on previously established principles [25]. The questions presented to participants were open-ended and aimed to elicit discussion [26] that uncovered the participants' experiences with eHealth, the challenges they faced, and their attitudes towards the use of eHealth in

interdisciplinary healthcare. Additional sub-questions and visual prompts were provided as required to ensure that the discussion among the participants was relevant to the research questions.

Four researchers assisted with facilitating the focus groups and collecting data: the primary moderator, assistant moderator, and two assistants. All four researchers took notes on the discussion, and the discussion was digitally recorded and later transcribed verbatim. The transcripts were de-identified to ensure anonymity of participants and organizations. The transcripts were checked for accuracy against the digital recording by the researchers. The final transcripts and a summary of key points were then emailed to participants for verification (member checking). No request for alteration to the transcript or summary was made by any participant.

Factor	**Focus group 1** [27]	**Focus group 2**	**Individual interview**	**Focus group 3**
Region	Regional New South Wales (Australia)	Regional New South Wales (Australia)	Metropolitan New South Wales (Australia)	Metropolitan New South Wales (Australia)
Organization type	Non-government organization	Government and community	Private and community	Government and community
Services provided	Public inpatient and outpatient rehabilitation	Outpatient rehabilitation services	Acute neurological acute care and rehabilitation	Public inpatient and outpatient rehabilitation
Disciplines of the health care professionals	• Speech pathology • Occupational therapy • Medical • Nursing • Care coordinator	• Speech pathology • Occupational therapy • Care coordinator • Social work • Administration	• Speech Pathology	• Speech pathology • Social work • Case manager
Years working in the team	• One over 10 years • One 5-10 years • Three 1-5 years	• Three over 10 years • Two 1-5 years • One less than 1 year	• Over 10 years	• Two 5-10 years • Two 1-5 years • One less than 1 year

Table 1 Summary of participant demographics

Phase 1 – Focus group data analysis

A traditional approach was undertaken for qualitative analysis of the transcripts and is based upon the simple analysis framework by Krueger and Casey [28]. This involved the three main steps of: categorization of raw data, descriptive statements, and interpretation of data. As part of the first step, two researchers independently analyzed and categorized data into categories. The categories of raw data were then cross-analyzed and discussed by a group of researchers to ensure consensus and reliability in the development of descriptive statements for each theme.

Once consensus was achieved on the themes and categories of the data, these descriptive statements were interpreted. As the analysis of focus group data involves a level of subjectivity, care was taken during the analysis to ensure that bias was not introduced in the interpretation of the results. We took into consideration any researcher preconceptions, the specific words spoken by the participants and the context of their statements, and the internal consistency and specificity of statements. To reduce subjectivity, findings were strengthened by having two researchers analyze the data independently, with the results and main findings then given to an independent reviewer for validation.

Phase 1 – Themes from the literature

The primary purpose of the literature review was to identify additional factors which infer the readiness of interdisciplinary healthcare teams to use eHealth technologies in the treatment of patients to improve health outcomes to achieve the development of a model with greater content validity [29].

The themes that were identified within the literature were extracted through a process of interpreting the literary work and summarizing the themes identified within each piece of work. Where such themes were recurring across works in the literature or aligned with the pattern of themes within the focus groups, these themes were flagged for inclusion into the factors that would be used in the initial conceptual model.

Phase 2 – Model factor formation
The Resource-Based View (RBV) [30] was used to provide a framework through which aspects of the organization could be described in the form of a resource giving rise to capabilities where such resources contribute to the performance of the healthcare team specifically and the organization more broadly [31]. Each resource was considered to be a tangible or intangible asset in which the organization has invested in financially, materially, or temporally, and from which the healthcare team can reasonably expect to gain some benefit.

Using this definition of a resource, the factors that were identified within the literature review and the themes that emerged from the content and thematic analyses of the focus groups were transformed into discrete resources. Each conceptual resource was recorded as one or more written sentences describing the principle entity within the resource and the nature of the factor or theme. Hypothetical examples were included with the construction of the given resource if it was thought that such inclusion would clarify the meaning of the resource for the user of the model. In following this process, a link can be made between each focus group theme or literature factor and the set of resources that will make up the model.

Phase 2 – Model structure formation
A pre-existing model structure was used in the initial formation of the conceptual model with the HOT-fit model being used [32] owing to the model's emphasis on the relationship and fit between the human, organizational, and technological factors in the environment [33].

The establishment of clusters of resources through the construction of three categories was performed with the categories being defined as: (i) User factors (analogous to the human factors) — which contained all resources where the healthcare team or the patient is the principle aspect of the resource, (ii) Organizational and external factors — which contained all resources relating principally to either the organization or factors external to the organization, and (iii) Technology factors — which contained resources principally related to the eHealth technology itself.

Due to the planned use of the Delphi methodology [add ref] with regards to the refinement and finalization of the conceptual model, the risk of information overload [34] was controlled through the use of sub-clusters to reduce the number of resources within each category of the model structure. Domains were established as categories of similar thematic content within the same cluster.

Phase 3 – Model content validation
The Delphi method [35] was used as the method to refine both the content and the structure of the model and to establish the content validity of the model [29] over a series of 3–5 iterations [36] allowing experts to systematically consider the complex problem of readiness measurements [37]. The stopping condition of the method is that of consensus being reached which is a satisfactory proxy for the content validity index's stated purpose as a measurement of consensus [38].

The recruitment of the experts for the Delphi method occurred through a snowball technique utilizing recommendations of an expert within the information technology field. Experts were selected based upon their expertise domain with the final make-up of the Delphi panel consisting of five experts; four of whom were from The University of Sydney Faculty of Health Sciences, and one from The University of Sydney Faculty of Engineering and Information Technologies. All five experts were present for each of the three rounds required to reach consensus and each provided feedback into the process. At the end of each iteration the feedback was incorporated into the model and the revised model presented for discussion at the next iteration.

Phase 3 – Model construct validation
Q methodology [39] in the form of several q sorts previously developed as part of prior research [40] was used to assess the construct validity of the model through the assessment of the correlation of multiple individuals' interpretation of the model resources [41]. If there is an appropriate similarity, then the interpretation of the resources and the placement of those resources within the model by individuals will be consistent with the theoretical a priori model, whereby construct validity can be established.

An open card sort and a closed card sort activity [42] were designed to have participants first sort all 59 of the resources of the model into four categories defined and named by each participant. Subsequently, the same participants then sort the same resources into four categories for which the names of the categories were given — the four names being those of the cluster names in the conceptual model. The participants were not aware of the names of the categories for the first sorting task. The card sort activities were performed using an online system and an offline system. Further construct validation is currently being undertaken using an online survey instrument to collect data for statistical validation.

Results and Analysis

The focus groups involved participants from organizations that provide services to the community with the aim of helping their clients transition back to their normal lives. While the team in focus group 1 (FG1) provide rehabilitation services for adults, the second and third focus groups (FG2 and FG3 respectively) provide rehabilitation services for both children and adults. The backgrounds of the three focus groups are similar, however FG2 and FG3 are managed under NSW Health while FG1 is managed externally to this network.

The participant from the individual interview (IP) is the principle of a Sydney metropolitan private practice that specializes in speech pathology services for adults with neurological impairments. Due to the nature of the industry, the participant operates as part of various interdisciplinary teams external to the practice on an ad-hoc basis.

Six main themes emerged from data analysis which are outlined in **Table 2**.

Theme	Overview
Organizational structure	• Positive attitude towards co-location for information sharing and case management.
Culture and attitudes towards technology	• Non-technology oriented clinicians. • FG1, FG3, and IP have positive attitudes towards eHealth. • FG2 less positive towards to impact and use of eHealth.
External organizations	• Lack of access to electronic records held by external organizations. • Effective resource location primarily reliant on networks developed by clinicians. • Limited information sharing with external organizations.
IT support	• Level of support variable across groups. • No co-located IT support for regional FGs. • Difficult for regional FGs to obtain timely support.
Technology, facilities, and infrastructure	• Wide use of different technologies e.g. tablets, smart phones, email, in-house administrative software. • Difficulties with data storage limitations on hospital servers for FG2. • Lack of support in most electronic medical records (EMRs) for non-textual data. • Lack of available IT facilities for regional FGs e.g. video conferencing equipment. • Variable internet quality for regional FGs. • Barriers such as cost, training, and client attitude exist with respect to client use of eHealth.
Policies and Guidelines	• Tight security model for FG1, FG2, and FG3. Some individuals unable to access emails, install apps, or visit certain websites such as YouTube. • Restrictions on text messaging and emailing photos. • FG1 and FG2 employees feel they are not trusted by the organizations and not empowered to use eHealth. • Cumbersome information sharing policies results in non-compliance and ignorance of policies in FG1, FG2, and FG3.

Table 2 Emergent Themes from Qualitative Study

Resource and structure formation

The operationalization of the themes from the qualitative study and the factors identified in the literature review resulted in the creation of an initial set of 44 distinct resources. These resources were categorized into three clusters: (i) the Organizational Capabilities cluster, (ii) the User Capabilities cluster, and (iii) the Technology Assets cluster. These categories were drawn from the HOT-fit model which was used as the initial foundational model for the structure formation. This structure and the contained resources were presented as the initial model for the consideration of the Delphi panel.

Delphi method implementation

The Delphi method was carried out over three rounds to determine the resources which would be used as a measure for each of the clusters of the model. At the completion of the third round consensus was given and it was deemed that the stopping condition, of reaching consensus, was achieved. The final model consisted of four clusters and 59 resources with 15 resources being included based on the feedback and agreement of the Delphi panel. Due to the consensus of the expert panel it was determined that the model possessed sufficient content validity.

Conceptual model construct validation

The q sort was undertaken to establish the construct validity of the model [29] where for a model with construct validity it would be expected that there would be convergence on the categorization of resources. The closed card sort was attempted by 12 participants and was successfully completed by 10 participants — that is they sorted all resources in the activity in a category. The participants of the sort were students from a health technology innovation class with individuals from clinical, health administration, and engineering backgrounds. The results of the sort were analyzed for convergence to identify which resources needing refinement. The evidence from the closed sorting task is that there does appear to be construct validity in at least three of the four clusters.

From the closed sort, there were six items of concern where less than 65% of the participants converged on the placement of the resource into a category — all six items were from the Technology Cluster. Additionally, there were two items — both from the Technology Capabilities cluster — which were categorized (with 70–80% convergence for both items) into a different cluster than that of the conceptual model. Where there is a miscategorization of a resource it must be determined whether the resource composition was the cause of the miscategorization or whether the participants interpreted the theme underlying the resource to be associated with a cluster different to that determined in the content validation phase.

The open card sort was attempted by 12 participants in total with 9 participants completing the activity. Overall 28 categories were created by 9 participants which indicated that some participants created greater or fewer than the four categories they were instructed to create.

The results of the open card sort were sorted into a hierarchical clustering using Ward's method [43] to determine the four clusters with the minimum within-cluster variance. The following themes emerged from the clustering: Organization, Users, electronic medical records (EMR), and Other Technology. However, the inter-cluster distance between EMR and Other Technology is minimal and it would be reasonable to merge them if the number of clusters was unrestricted. The emergent clusters while not significantly dissimilar to the proposed model do not reflect the expected clustering in some cases.

Discussion

The results from the qualitative study confirmed the issues raised in existing literature, including the need for rigorous evaluation of eHealth and the importance of considering the technology-environment fit. The findings also moved beyond the literature and present a conceptual model to measure the eHealth readiness — that is the technology-environment fit — of interdisciplinary healthcare teams. One of the most interesting findings from the study is that although the clinicians faced a number of challenges with regards to the use of eHealth and were unable to achieve the full benefits that it can offer, they presented positive attitudes towards eHealth. The majority of issues highlighted by the study are touched upon in the literature, however the focus is still largely on the technological aspects of evaluation such as functionality and the quality of the system, rather than having an equal focus on the external and environmental impacts on technology. Without understanding the inclusion of organizational factors such as procedures, policies, infrastructure, or even if the technology is effective, it is not likely to be successfully implemented. Thus, factors from both health technology and health informatics evaluation should be drawn to provide the foundation for a rigorous eHealth evaluation model that considers both the effectiveness of technology and the fit of technology within its environment.

Proposal of a health technology evaluation model

This study highlights the gaps within literature regarding the evaluation of eHealth within organizations. In particular, there is no evaluation model that considers the environment of health technology implementation within the context of a healthcare team and which includes factors such as the team or the organizations. The effect of this gap can be seen in the study, where eHealth was implemented with the belief that it can improve processes and client care, however these desired results were not observed. The results indicate that there is a lack of emphasis on particular elements in the evaluation of eHealth in literature such as infrastructure and policy. In the literature, many of these issues are often overlooked as being of lesser importance to factors such as technological and user impacts.

We propose a conceptual model that aims to integrate the two evaluation processes and bridge the gap between the evaluation of the health technology itself and the evaluation of the fit between the technology, its environment, and its users. These two processes need to be integrated to determine whether the technology is effective and safe to use, as well as consider the type of organization or individual that the technology is suited for. The proposed model consists of four clusters each containing domains which give rise to capabilities found to allow healthcare teams to implement and effectively use eHealth technologies for the improvement of patient outcomes. Current literature indicates the

challenges faced in the evaluation of non-traditional health technologies such as eHealth, however there is no coherent solution to bridging the gaps between the existing models. Thus, the proposed framework attempts to integrate health technology evaluation and health informatics evaluation to provide a means for the holistic evaluation of eHealth readiness in healthcare teams. The conceptual model (outlined in **Error! Reference source not found.**) consists of four clusters: (i) External Factors, (ii) Team Capabilities, (iii) Patient Capabilities, and (iv) Technology Capabilities.

Cluster	Domain	
External Factors	• Policies Asset • Procedures Asset	• Implementation Asset • Cultural Asset
Team Capabilities	• Team Training Asset • Technology Use Asset	• Leadership Asset • Communication Asset
Patient Capabilities	• Patient Value Asset	• Patient Ability Asset
Technology Capabilities	• EMR Asset	• Technical Asset

Table 3 Conceptual Measurement Model Clusters and Domains

External Factors

The External Factors cluster (Table 4) comprises the set of domains that the clinical team cannot reasonably expect to be able to materially influence, change, or mitigate through intentional action.

Domain	Description
Policies Asset	Quality of documents and resources outlining the vision and strategy of the organization concerning eHealth.
Procedures Asset	Quality of documents and resources providing concrete guidelines on the use of eHealth by healthcare teams.
Implementation Asset	Ability of the organization to carry out the operationalization of policy and procedure.
Cultural Asset	Ability of the organization to affect change in behavior of the healthcare team with respect to eHealth use.

Table 4 External Factors: Domains and Descriptions

Team Capabilities

The Team Capabilities cluster (Table 5) refers to the readiness of a team working in a collaborative manner to deliver healthcare services to patients using eHealth technologies.

Domain	Description
Team Training Asset	Degree of training that a healthcare team has undergone regarding the use of eHealth, its integration into practice, and the effective operation as an interdisciplinary team.
Technology Use Asset	Measure of the use of eHealth by the healthcare team, the level of technology literacy of the healthcare team, and the extent of difficulties in using eHealth.
Leadership Asset	Activeness of the healthcare team's diffusion of eHealth within the organization.
Communication Asset	Ability of the healthcare team to communicate ideas and concerns effectively and efficiently with external entities and within the team.

Table 5 Team Capabilities: Domains and Descriptions

Patient Capabilities

The Patient Capabilities cluster (Table 6) measures the perceived and measured capabilities of the collective patients treated by the healthcare team to utilize eHealth practices and technologies in improving clinical outcomes. If the patients receiving treatment from the healthcare team are on average unable to use eHealth technologies then the team is as a function of this unable to use eHealth technologies in the patient care and as such the measured readiness of the team to use eHealth technologies will be low or non-existent.

Domain	Description
Patient Value Asset	Measure of the value that the patient is expected to realize from the use of eHealth technologies based on patients' perceived usefulness of eHealth.
Patient Ability Asset	Ability of the patient to extract value from the use of eHealth through two dimensions: (i) digital literacy and (ii) health literacy.

Table 6 Patient Capabilities: Domains and Descriptions

Technology Capabilities

The Technology Capabilities cluster (Table 7) seeks to provide a measure of the sufficiency of eHealth technologies, the support provided for those technologies, and the physical access afforded to those technologies in allowing for clinical teams to improve the health outcomes of patients. It is anticipated that a high measure in this cluster would correlate with increased efficiency of administrative tasks, increased availability of patient information, the timely provision of information technology support, or the provision of appropriate devices and internet infrastructure to allow for clinical teams to access patient information and other health information when required.

Domain	Description
EMR Asset	The level of integration of the EMR system used by the clinical team has with other systems in the organization such as in the automatic sharing of data and information between systems.
Technical Asset	The ability of the healthcare team and patients to access and obtain support for eHealth technologies used in the care of patients.

Table 7 Technology Capabilities: Domains and Descriptions

Limitations

There are a number of inherent methodology limitations concerned with the qualitative study, the Delphi panel, and the q sort used. The content and thematic analysis conducted on the data from the qualitative study was based on limited non-saturated data which was subsequently supplemented by literature. Owing to this non-saturation it may be that the content validity of the model is limited. The experts used in the Delphi panel were drawn from a pool of individuals from the same research group. This limitation may cause the content validity of the model to be weaker than anticipated. The population used for the q sort had several limitations including that they may not have been representative of the wider healthcare population, that none of the participants were regionally based, and that the population used was small. Additionally, a varying number of categories were created per participant. This will affect the hierarchical cluster analysis as the distances between resources may result in the cluster formation not being representative of the participant's intent. Further construct validation is as such being currently carried using an online survey instrument being disseminated to healthcare professionals.

Conclusion

Health technologies and eHealth specifically have the potential to transform the delivery of healthcare services to patients for the purposes of improving health outcomes and quality of life for those patients. Such use of technologies however, is expensive and sustainable expenditure must be established within the framework of existing healthcare systems. Additionally, the value of eHealth technologies used in the delivery of healthcare services is limited by the skills, knowledge, and support available to both healthcare teams and patients — where an ineffective environment for the engagement with such technologies minimizes any beneficial outcomes that may be obtained from the use of the technologies.

The methodology framework has led to the proposal of the four-factor model with content validation and initial construct validation being found. Further work is currently being undertaken to provide construct validity of the measure using an online survey instrument. We believe that this conceptual model provides a foundation for the aggregation of multi-discipline constructs for the purposes of the creation of a measurement model. This model specifically targets interdisciplinary healthcare teams and their readiness to use eHealth and provides at the least a validated set of resources which should be considered for inclusion into future quantitative models.

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