



Research article

Maintaining a social license to operate for wastewater-based monitoring: The case of managing infectious disease and the COVID-19 pandemic

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ABSTRACT

Wastewater monitoring as a public health tool is well-established and the SARS-CoV-2 (COVID-19) pandemic has seen its widespread uptake. Given the significant potential of wastewater monitoring as a public health surveillance and decision support tool, it is important to understand what measures are required to allow the long-term benefits of wastewater monitoring to be fully realized, including how to establish and/or maintain public support. The potential for positive SARS-CoV-2 detections to trigger enforced, community-wide public health interventions (e.g., lockdowns and other impacts on civil liberties) further emphasises the need to better understand the role of public engagement in successful wastewater-based monitoring programs. This paper systematically reviews the processes of building and maintaining the social license to operate wastewater monitoring. We specifically explore the relationship between different stakeholder communities and highlight the information and actions that are required to establish a social license to operate and then prevent its loss. The paper adds to the literature on social license to operate by extending its application to new domains and offers a dynamic model of social license to help guide the agenda for researcher and practitioner communities.

1. Introduction

The impact of the COVID-19 pandemic on societies has been immense and the pace at which scientific communities have responded to combat the virus to protect public health was unprecedented. This rapid response has been evident in multiple fields of science, including wastewater monitoring research (e.g., Ahmed et al., 2020a,b). As the world scrambled to meet the challenges of the rapidly evolving pandemic, wastewater monitoring for fragments of the SARS-CoV-2 virus emerged as a technology that could provide valuable early warning of COVID-19 outbreaks (World Health Organization, 2020; Medema et al., 2020). Across numerous jurisdictions researchers have used

wastewater monitoring to help understand the status and evolution of the pandemic in local jurisdictions (Ahmed et al., 2020; Medema et al., 2020; Peccia et al., 2020; Wu et al., 2020).

The success and well-established use for community-scale pathogen monitoring in other contexts (e.g., poliovirus; Böttiger and Herrström, 1992), needs to be considered against a context where wastewater monitoring is being used for the first time to trace a novel virus in the midst of a global pandemic (Hill et al., 2020). The lack of precedent makes for exciting scientific discoveries, but also adds potential risks (e.g., Gable et al., 2020). It is possible to conceptualize at least two broad groups of risks. One category of risk relates to scientific community practices and how they interact with emerging science and subsequently

Abbreviations: State and Territory abbreviations: VIC, Victoria; SA- South Australia, WA- Western Australia; QLD- Queensland, NT- Northern Territory; ACT, Australian Capital Territory; NSW, New South Wales; TAS, Tasmania.

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develop into accepted governance arrangements. A second category of risks relates to the acceptance by the broader community of these types of surveillance practices. More specifically, communities might reject wastewater monitoring if it is viewed as too intrusive or unnecessarily impinging on individual freedoms. Clearly, these two categories are not strictly independent and ultimately combine to determine what is required to build and maintain community trust around wastewater monitoring.

Prima facie wastewater monitoring has been well accepted by the public to date, but this apparent acceptance of public health measures arising from positive SARS-CoV-2 detections cannot be taken for granted. There is also emerging evidence that segments of the population are more likely to question the role of government and their surveillance approaches as the impacts of the pandemic drag on (Devine et al., 2021; Evans, 2021; Gray et al., 2021; Hartley and Jarvis, 2020; Schmelz, 2021). The expanded and continued use of this type of monitoring in the future to support a variety of 'public good' applications will thus rely on maintaining community acceptance for both practical and normative reasons.

One way to approach this challenge is to invoke the notion of social license to operate; a concept widely deployed in mining and forestry sectors, and increasingly useful for understanding dynamic interactions where failure to meet community expectations may lead to the cessation of an organisation's activity. Social license to operate has been acknowledged as highly context specific (Zhang et al., 2015). It derives directly from shifting community expectations around acceptable environmental practices (Moffat et al., 2016), and allows for investigation of elements that would risk the erosion of existing public acceptance and trust, as might occur in the current context if wastewater surveillance is performed at a scale that allows individual cases to be located or identifiable.

A previously claimed benefit of wastewater monitoring was that it was undertaken at a population-scale and individuals could thus remain anonymous. Moreover, this argument has been used as the basis for not requiring human ethics approval as part of wastewater monitoring research (Prichard et al., 2016). However, the pandemic has seen wastewater monitoring investigations move further up sewer catchments to target smaller sewershed population subsets (e.g., Hassard et al., 2021), and this has been accompanied by more targeted insights that move beyond relatively simple positive detections of SARS-CoV-2 RNA fragments (presence/absence) to complex correlation analyses and deep learning approaches. For instance, Hassard et al. (2021) report that Near-Source-Tracking was being used in several countries including Estonia, Finland, France, Singapore, Turkey, the UK, and the USA. In some cases, this can operate at the sub-building level to identify small clusters or even individual cases. Researchers are also looking ahead to future applications of wastewater monitoring and are beginning to explore the relationships between human biomarkers in wastewater and social, demographic, and economic parameters of spatially resolved populations (Choi et al., 2018, 2019).

As advanced analytics and artificial intelligence are increasingly applied to interrogate large datasets, deeper insights can be gained, but new ethical challenges arise that arguably need to be acknowledged to avoid loss of trust (Shaw et al., 2020). The assumption that information cannot be linked back to individuals may not hold true in all scenarios, even where precautionary measures are taken to help maintain data privacy; particularly as genetic sequence analysis becomes faster, more affordable, and more sophisticated. It is important that those contributing to the field proactively reflect on the social and ethical issues as the technology advances (Jacobs et al., 2021).

Adding to this challenge is the significant number of wastewater monitoring researchers that have not previously worked with public health agencies. This cadre of researchers may not be familiar with the ethical obligations necessary when evidence is communicated to the public and/or is being relied upon to make public health decisions (Canadian Water Network, 2020). Globally, many scientists working in

wastewater microbiology have pivoted to focus their efforts on SARS-CoV-2 monitoring in a bid to contribute to the COVID-19 pandemic response (Larsen and Wigginton, 2020). Often, this change of direction has brought them into unknown territory in terms of ethics and stakeholder engagement, including dealing with the mass media. The potential for positive SARS-CoV-2 detections to trigger sometimes coercive or large-scale public health interventions (e.g., lockdowns and other impacts on civil liberties) further emphasises the need to better understand how researchers' public engagement might impact on public acceptance.

This paper systematically reviews the processes of building and maintaining the social license to operate wastewater monitoring, adding to the literature on social license to operate by extending its application to new domains. We specifically explore the relationship between different stakeholder communities and highlight the information and actions that are required to establish and then prevent loss of social license to operate. In addition, we develop a dynamic model of social license while providing a contribution to both researcher and practitioner communities with a framework to guide further research on this topic. While the analysis is applicable broadly, we use the experiences in Australia to help shape the framework. Our rationale is that the initial response in Australia to COVID-19 has been described as 'exemplary' by many (e.g., Johnston, 2020; Hyland-Wood et al., 2021) and enjoyed strong public support. However, recent developments with new variants of the disease and gaps in government responses are increasingly drawing criticisms. These changing circumstances thus provide a useful backdrop for analysing the dynamics of social license in general.

The paper comprises the following sections. In section two we offer a precis of the responses of government to COVID-19 to provide a backdrop to the analysis. The notion of social license to operate is scrutinized and stylised models around the development and maintenance of social license to operate are reviewed in section three. Section four builds from these models to generate a framework applicable to the dynamics of a new technology, like wastewater surveillance, emerging in the context of a pandemic. This is followed by a review of the emerging practices that characterize wastewater monitoring as part of the COVID-19 response and positions these practices as part of the social license to operate in section five. The final section distinguishes key areas for further work and provides brief concluding remarks.

2. A precis of government responses to COVID-19 in Australia

Australia is a federated democracy where states and territories retain major responsibilities related to health and environmental management. Australia retains a constitutional monarch – the Queen – who is represented nationally by the Governor-General. The national government holds responsibility for quarantine, immigration and defence but also has most fiscal power, given its control over income and goods and services taxation. This creates a vertical fiscal imbalance between subordinate and national governments along with a degree of legislative and administrative complexity that constrained governments' responses to COVID-19. The first Australian case of COVID-19 was reported in Melbourne, on January 25, 2020. On the same day another three cases were reported in Sydney, all related to international travel. Relative to other countries, Australia moved quickly in early February to contain the virus by limiting the entry of foreign nationals from mainland China and by requiring Australians returning from mainland China to self-isolate for 14 days.

By March 11, 2020 WHO had declared COVID-19 a pandemic and a National Cabinet, comprising the heads of the national, state and territory governments, was instated by 13th March. The National Cabinet aimed to provide a coordinated response to the pandemic, leaving national, state and territory governments with their usual implementation and management responsibilities. A human biosecurity emergency was proclaimed by the Governor-General under the Commonwealth Biosecurity Act on 18th March. By 15th March the state and territory

governments had already begun imposing restrictions on the social movement of their citizens, largely by invoking sections of public health acts and declarations of health emergencies. These restrictions included mandated isolation for anyone arriving in the country after the 15th March or with symptoms related to COVID-19. Other controls were progressively imposed across states and territories, like limiting the size of gatherings, restricting visitation to aged care facilities and requiring that individuals retain a social distance of 1.5 m. COVID-19 testing regimes were also implemented, with Australia having one of the highest testing rates in the world at the time, thanks to its universal healthcare system (Duckett and Stobart, 2020).

At the national level, the border was closed to all non-Australians from 20th March and hotel quarantine, rather than home quarantine, was progressively introduced. Some states and territories also closed borders to interstate travellers in the following days. The public communication for these changes was shared between health officials, law enforcement representatives and political leaders, with daily and sometimes hourly updates provided to communicate COVID-19 case numbers and updates on changing public health orders and directions. Overwhelmingly, the emphasis was on reducing community transmission of the virus with the stated aim of protecting the health of the most vulnerable by avoiding inundation of health services. Interest began to emerge amongst scientists about the viability of helping inform health advice through wastewater surveillance.

The National Cabinet agreed to impose laws that prohibited the opening of many businesses, initially focussing on the hospitality and entertainment sectors, but applying more broadly by the end of March 2020. Schools remained open in some states although parents of so-called 'non-essential' workers were encouraged to keep children at home. In some states these changes required new legislation (e.g. NSW's COVID-19 Legislation Amendment- Emergency Measures – Bill; Queensland's COVID-19 Emergency Response Act 2020) and in other cases provisions were activated within existing legislation (e.g. South Australia's Emergency Management Act 2004). Given the focus on 'elimination' of transmission, laws were also imposed requiring individuals to use smartphone check-in codes when purchasing essential items to facilitate contact tracing where infection arose; close contacts of infected individuals were then required to self-isolate.

Relative to other nations that struggled to prevent the collapse of health systems, Australia fared well at this time (Duckett and Stobart, 2020). A significant government fiscal support program was required to cushion the economic consequences of 'lockdowns' and this was shared by national and state/territory governments. In May 2020, National Cabinet agreed on a 3-step plan to progressively ease local restrictions while keeping international borders closed. Subsequent outbreaks resulted in state-based lockdowns, with Victoria the most impacted. As the second wave took hold, a nationally collaborative project involving the water industry, health regulators/departments and expert wastewater scientists was established, known as the 'ColoSSoS' Project (Collaboration on Sewage Surveillance of SARS-CoV-2). The purpose of the project was to support best practice and provide a coordinated national approach to wastewater monitoring for SARS-CoV-2.

A national vaccination program commenced on February 22, 2021, but the staged roll-out prevented the full abandonment of lockdowns, especially with the emergence of the Delta variant of the virus in June 2021. Towards the end of 2021, some state and territory governments became buoyed by relatively high vaccination rates and were further encouraged by the national government to ease restrictions. This occurred regardless of the emergence of the Omicron variant in November 2021, with governments shifting attention to hospitalisation and death rates rather than transmission and new infections *per se*. By the end of 2021 international borders were open to vaccinated individuals and interstate travel resumed. Throughout 2022 the emphasis has been on 'living with COVID-19' with few mandated behavioural restrictions but strong encouragement for vaccination boosters. A stylised representation of government responses to COVID-19 appears as

Fig. 1.

Regardless of the shift in focus towards living with the virus and aiming to limit hospitalisations, wastewater monitoring has become an ongoing part of the COVID-19 reporting landscape for most states (e.g. NSW Health, 2022). Weekly updates categorized by treatment plants are common and sub-catchment sampling techniques have emerged and been refined (Donner et al., 2021). Understandably, much of the emphasis has been on enhancing the technology to assist with the pandemic response, and formal analysis of communities' acceptance of the technology has not yet occurred. This raises questions about the extent to which wastewater monitoring will retain social license in the future.

3. Theoretical and practical perspectives on the development and maintenance of social license to operate

The notion of social license to operate first emerged in the literature in the 1990s (Thomson and Boutilier, 2011) and was initially associated with the shift in community expectations around mineral extractive industries that had built up over the preceding three decades. More specifically, the emergence of stronger societal views around preservation of natural resources and the requirement of communities to have their local environment respected began to challenge the establishment of mining projects. This subsequently led to a recognition of the range of potential costs to mine operators (Franks et al., 2014), if community discontent reached a level that halted or curtailed operations.

At a practical level, monitoring the behaviour of mine operators has been linked to social license. While much of the monitoring of mines hinges on environmental issues – like the storage and treatment of tailings or practices to prevent damage to water resources or biodiversity – social and economic aspects are increasingly emphasised as part of best practice in the sector (Department of Industry Science and Resource, 2011). On the socioeconomic front, monitoring and reporting on local and regional economic adjustment is seen as important and has a significant bearing on social license. In addition, engaging with the community to participate in environmental monitoring is now commonly regarded as an appropriate step to secure license. The spatial and temporal scope to achieve best practice has also expanded beyond the immediate and surrounding environments to include international considerations and the impacts on future generations through post-mine operation and relinquishment. Best practice monitoring in mining also implies that communities are engaged in the design of monitoring programs; that the monitoring itself uses the best available methods; information from monitoring efforts is transparent and available; and there is scope for auditing (Department of Industry and Department of Foreign Affairs and Trade 2016).

From its origins in the mining industry, the construct of social license to operate has been deployed to consider forestry practices (e.g., Edwards and Lacey, 2014), agricultural developments (Shepherd and Martin, 2008) and manufacturing (e.g., Gunningham et al., 2004). More recently, the idea of social license has been applied to data-intensive activities, like artificial intelligence (Evans-Greenwood et al., 2020) and financial technology (Aitken et al., 2020). At the time of writing, the construct has never previously been applied to the analysis of wastewater management and surveillance.

The evolution of the application of social license to operate from the mining to the forestry sectors highlights an important generalisable principle underlying the construct. As noted by Moffat et al. (2016), "both [mining and forestry] sectors also share a number of similarities in terms of the recognition and management of the environmental and social impacts of their operations" [emphasis added]. In the case of wastewater monitoring, we contend that the recognition and management of social impacts is of sufficient gravity to warrant the use of social license as an analytical tool. The requirement of communities to relinquish and sanction the use of potentially private information harvested from wastewater science for the perceived greater good, lies at the core

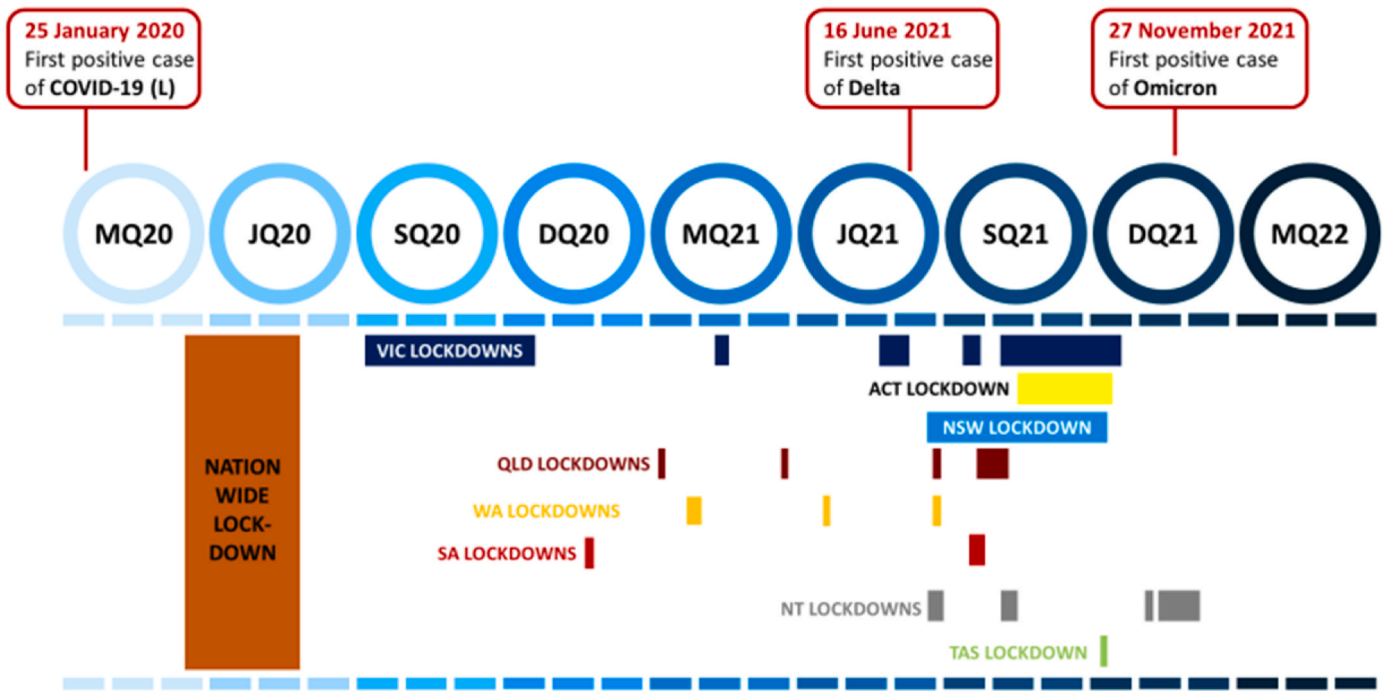


Fig. 1. Timeline of COVID-19 pandemic evolution in Australia and subsequent government-imposed lockdowns (Source: ABS, 2022).¹¹.

of these potential social impacts.

Some theoretical analyses of social license to operate have been developed (e.g., Moffat and Zhang, 2014; Thomson and Boutilier, 2011), although the deployment, testing and refinement of theoretical models is arguably incomplete. Social license theorists like Thomson and Boutilier (2011) initially conceptualised the idea of social license as comprising layers where lower levels of social license constitute greater risks to an operation. Refining their layered approach through studies of mines in Mexico, Australia, and Bolivia they identified four factors comprising economic legitimacy, socio-political legitimacy, interactional trust, and institutionalised trust, as underpinning social license. Moffat and Zhang (2014) offer an alternative conceptualisation of social license and its antecedent features, again using mining as the background to their work. Drawing on the social psychology of groups, Moffat and Zhang (2014) offer a model where community trust is seen as the key predictor of acceptance of an activity/operation. The community’s trust is further related to the impacts on social infrastructure, the quantity and quality of contact between the operator and the community and the procedural fairness that ensues from any dealings between the community and the operator. In this model, trust comprises two elements: the first relating to the operator following a set of principles and the second tied to the competency of the operator. The impacts on social infrastructure are a composite of the positive and negative effects of the activity (e.g. changes in employment patterns, wealth) and the extent to which the actual impacts mirror the promised or expected results, which feed directly into community trust. Increasing the amount and calibre of contact between the operator and the community is hypothesised to “engender goodwill and trust” (Moffat and Zhang, 2014), in turn lifting the level of trust and ultimately acceptance. The perception that the operator makes decisions in a fair and considered manner is the final element in Moffat and Zhang’s (2014) model. Providing communities with voice to air concerns and demonstrating that those concerns are treated seriously is seen as central to building trust, even if the decision ultimately does not favour a particular party. Their conceptual model is depicted in Fig. 2.

In order to validate their model, Moffat and Zhang (2014) collected data from two groups in a region impacted by a coal-seam gas development. The subsequent path analyses were used to test the extent to

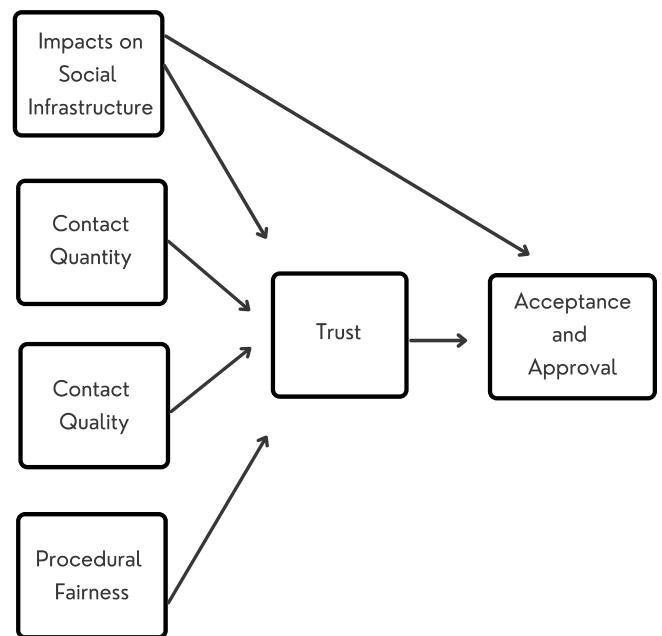


Fig. 2. Overview of relationships between social license concepts (Moffat and Zhang, 2014).

which the factors in Fig. 2 ultimately influenced trust and acceptance of the coal-seam operation. This was undertaken using a range of Likert response items drawn from the literature and showed that procedural fairness and contact quality were the main influences on community trust and acceptance. Impacts on social infrastructure were also positively related; although relatively weakly in this case, and contact quantity had no bearing on trust. Notwithstanding the novel contribution of Moffat and Zhang (2014) in quantifying social license to operate, significant limitations remain. Amongst these is the context-specific nature of their empirical work, at least in terms of geography, timing

and sector specificity.

In subsequent analyses of social license, the dynamic nature of relationships between communities and industry operators has been noted (Moffat et al., 2016). Arguably this component is not well captured in the existing models. There is also a presumption in the existing models that license/acceptance is linear and built from trust. It is not clear from the existing models how a novel and largely unknown operation/activity, like wastewater surveillance for COVID-19, gains the initial trust of communities and maintains that trust to preserve social license (e.g., Hurlimann and Dolnicar, 2010). It is also not clear how the crisis nature of a pandemic impacts on social license in these models, nor how the persistence of wider government controls over individual behaviours might interact to strengthen/weaken that license. To bridge this gap, we propose an alternative model that (a) disaggregates trust and trustworthiness in the absence of initial experience and (b) incorporates the dynamics of information flows in a pandemic.

4. Towards a dynamic model of trust and social license to operate

Blomqvist (1997) offers one of the early syntheses of trust by drawing from a diverse body of work including social psychology, philosophy, economics, marketing, and contract law. She ultimately settled on a working definition for trust in business contexts, suggesting that trust is: "... an actor's expectation of the other party's competence and goodwill" (Blomqvist, 1997, p. 282, p. 282). Whilst helpful as a starting point and mirroring others who highlight the necessity of perceived competence and procedural and distributional fairness (e.g., Moffat et al., 2016; Moffat and Zhang, 2014), it is important to understand how such expectation might be formed in the first case. How does an individual or a community formulate perceptions about competence and goodwill for a new and novel technology?

In this regard, Andras et al. (2018) describe the notion of second-order trust. Here, trust is generated by trusting the opinions or judgment of others. Put differently, this is not about trusting the technology *per se*, but perceiving the entity currently using or promoting the technology as being trustworthy. Aitken et al. (2020) argue that second-order trust:

"Is particularly salient around new technologies and services, where early adopters are likely to have either high technical knowledge or propensity to risk-taking. Wider adoption of the technology or service will depend on trust building up through social networks emanating from these early adopters" (Aitken et al., 2020, p. 6, p. 6)

If we accept the importance of second-order trust in the context of wastewater surveillance as a new technology, it follows that the initial formulation of trust that underpins social license must come from the community's interactions and/or relationships with actors who are using the technology. While we are not arguing that the community will 'use' the technology, they must nonetheless adopt the information that comes from it. Thus, the perceptions about public officials who are called upon to announce the results from wastewater surveillance appear paramount in the initial phases of establishing trust and achieving social license.

Over time, it seems plausible that different elements will come to bear on the community's assessment of trust and the work of Dietz and Den Hartog (2006) can help conceptualize those dynamics. Using the trust framework of Mayer et al. (1995), comprising ability, benevolence and integrity (ABI), they note the importance of predictability as a means of sustaining trust. In the ABI framework, ability is equivalent to perceived competence, benevolence implies the trustee is perceived to do good to the trustor and integrity relates to the trustee being perceived

to have and act within a set of reasonable principles. The ABI + framework of Dietz and Den Hartog (2006) goes further by noting the compounding nature of predictability as a means of emphasizing an entity's ABI. Predictability thus becomes key in maintaining trust over time and is consistent with Fox's (1974) assertion that trust builds trust and can be reinforcing. Moffat et al. (2016) conclude that predictability in approach and fairness are likely more important than predictability about an activity. In that context, distributional and procedural fairness and confidence in governance are likely required to sustain social license, while the perceptions of proponents are the basis for the initial formulation of trust and sanctioning. Drawing these conceptual threads together results in the model depicted in Fig. 3.

In this model, the initial basis of acceptance and social license (i.e., T_i) is contingent on second-order trust. This relates specifically to the trust in the proponents or early users; in the case of wastewater surveillance this might be construed as the public officials communicating information to the community about SARS-Cov-2 in wastewater streams. In the absence of any compelling evidence to reconsider the initial assignment of trust and acceptance, the community might continue to rely on this as their only source of validation. This is signified in Fig. 3 with the upper feedback loop. Over time and with changes in the wider context, such as recognition of the links between wastewater data and other constraints imposed by government, communities begin to use an alternative feedback loop to validate and review the initially assigned level of social license. This is signified by T_{i+n} . In this case, communities embark on a more detailed examination of the components that underlie trust and acceptance and allocate their ultimate valuation to the users and proponents. This is also informed by the level of predictability witnessed by the community. Arguably, this might morph again with communities placing greater store in their own perceptions of fairness, governance, and predictability in general, and, devoid of any reference to the users/proponents of the technology reach an assessment of trust and acceptance.

It is important to acknowledge that, in this model, the antecedent components of distributional and procedural fairness and governance capacity are likely interlinked and potentially substitutable. For example, entities will likely be viewed as having greater governance capacity when they act in a seemingly fair way. Alternatively, by acting fairly the community might acquiesce on weaknesses in governance. This aligns with the initial ABI framework of Mayer et al. (1995) where exceedance on one front can compensate for deficiencies on others, in order to secure trust and social license to operate. It is also important to acknowledge that these components are not necessarily static; rather they might modify as concerns from the community become apparent and adaptations are made to better align with community expectations and values.

5. Assessing the status of social license for wastewater monitoring

5.1. Institutional context

Wastewater monitoring lies within a genre of work known as wastewater-based epidemiology (WBE). WBE is based on the analysis of chemical and/or biological compounds in sewage and has an established history of utility in assessing population-scale public health from the perspective of both chemical (recreational and prescription drugs) and biological (pathogenic) markers (Choi et al., 2018; Daughton, 2018; Finkel, 2021). Wastewater monitoring can be traced back at least to the 1940s when cell-culture methods were used to monitor for polio and other viral pathogens and the near eradication of polio in Australia is partly attributable to wastewater monitoring. Molecular techniques, like hybridization with cDNA probes emerged in the 1980s to track Hepatitis A, while polymerase chain reaction (PCR) methods became more common in the 1990s, partly because of their improved sensitivity (Schmidt, 2020). Wastewater monitoring is also used to monitor the use of illicit

¹ Timeline abbreviations: MQ – March Quarter; JQ – June Quarter; SQ – September Quarter; DQ – December Quarter.

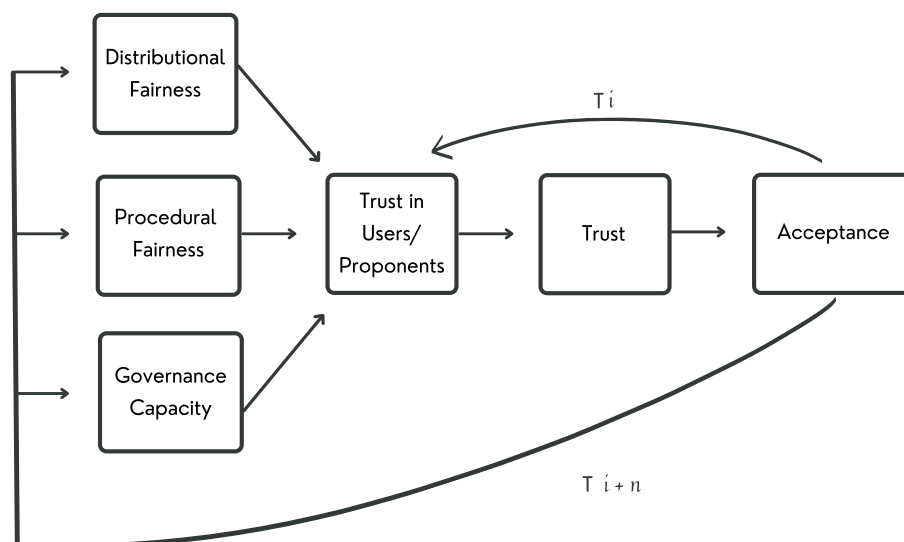


Fig. 3. A dynamic model of license to operate (source: authors).

drugs by communities (see, for example, Australian Criminal Intelligence [Australian Criminial Intelligence Commission, 2022](#)).

Prior to the pandemic, wastewater governance and monitoring occurred under the various state and territory legislative frameworks. Once wastewater enters a communal sewer network the rights to that wastewater shift to the owner of the network; in most cases a government-owned utility. In some instances, entities cannot discharge wastewater to the network without meeting specific conditions – e.g. food distribution outlets must limit grease entering the network – and this is monitored to protect utility infrastructure. Given the historical focus on managing health risks, most wastewater regulations derive from public health acts. For example, in South Australia, the Public Health Act (2011)(1) circumscribes the South Australian Public Health (Wastewater) Regulations (2013). Moreover, Part 5 of these regulations allows for an authorised officer to “take samples of a substance or thing for analysis” (p. 17). Environmental aspects of wastewater in that state are also covered by the Environment Protection Act and associated Water Quality Policy.

The proclamation of a human biosecurity emergency by the Governor-General and the accompanying emergency declaration in states and territories in March 2020 meant that Chief Medical Officers (and in some cases Police) assumed much more discretionary power than would otherwise be the case. The notion of a Chief Medical Officer stems from Victorian England when communities were faced with cholera and typhus outbreaks. The office “straddled the boundaries among politics, medicine and public health” but appointees generally hold a medical background and “[t]his authority and expertise also enhance the likelihood that the public will perceive them and their messages as credible and trustworthy” (MacAulay et al., 2022, p. 101). In Australia’s case, there is a Chief Medical Officer at the national level, but because the bulk of responsibilities related to health reside at sub-national level, this office has relatively limited legislative powers. At the sub-national level, the office usually assumes the name of Chief Health Officer and conventionally would be tasked with providing advice to the Health Minister and other senior bureaucrats responsible for managing the health system. However, under emergency declarations the role assumes more ‘control’ and in some cases because the role is also assigned ‘director-general’ status can mandate changes with limited consultation with government. Harris et al. (2021) contend that this is most pronounced in the state of Queensland, although New South Wales invests similar authority in the office. In other jurisdictions, like

South Australia, ultimate control under an emergency declaration is vested in the Police Commissioner, but the Chief Health Officer’s advice directly shapes behavioural mandates that have health implications.

As noted in section 2, a national program around wastewater monitoring emerged in the form of the ColoSSoS project led by Water Research Australia in 2020 and covered multiple state and territory jurisdictions. The focus of the ColoSSoS project has been on the rapid development and application of sensitive and robust methods to deliver results to government and the community. The ambition of ColoSSoS was to provide wastewater monitoring data for health regulators to integrate with other health information and thus offer early advice on appropriate interventions. The medium and longer term aim of ColoSSoS is to have WBE embedded in health regulator decision making as an early warning technology (Water Research Australia, 2021). The agenda to build ‘community’ confidence around the technology is in development. State Department(s) of Health have made some steps towards making information publicly available via dashboards and websites, however, the longer-term program is yet to fully develop.

5.2. Assessing initial trust

In the context of the model presented in Fig. 3, the role of second-order trust may be pivotal for the community acceptance of wastewater monitoring and the institutional setting described above has a significant bearing.

More specifically, the prominence of the health statutes, as part of this response, has meant that for most Australians the likely direct proponent/user of wastewater monitoring derived information is the health spokesperson for each state jurisdiction. In proposing recommendations for improving communication about COVID-19, Hyland-Wood et al. (2021) specifically highlight the important role of health officials to date:

“Strategies for achieving maximum credibility during a pandemic response include leveraging trusted, authoritative intermediaries such as medical and public-health experts to communicate key messages. To an extent, such roles are hard-wired into the public-health governance of many countries (e.g., Chief Medical Officers in some Commonwealth countries), although this does not guarantee that governments will listen to the expert’s advice and support them in their role”.

Others (e.g., Funk et al., 2020) have noted that trust in healthcare professionals, scientists, and medical experts has generally remained high since the pandemic and this seems to have been the case during the initial response phases to COVID-19. Against that background, it seems plausible that the social license around wastewater monitoring in Australia resides primarily in the *Ti* cycle, at least until late 2021. Moreover, there is a body of evidence that supports the view that this is currently enjoying a virtuous phase with repeated media reports emphasizing trust in the state's health bureaucrats. For example, Robertson (2021) notes that in the case of Queensland's Chief Health Officer (i.e. Dr Jeanette Young), where legislative powers of the office are considerable, "She is widely respected in her field and has earned public trust in her time in the limelight". In Victoria, Simons interviewed Professor Brendan Crabb, Director of the respected Burnet Institute about the public persona of the state's Chief Medical Officer and he noted the following of Professor Brett Sutton: "To be able to say after all that he's consistent and calm and trusted and modest and respectful and clear is incredible ... I know I couldn't be that person" (Simons, 2020). In South Australia the Chief Public Health Official, Professor Nicola Spurrer was nominated as Australian of the Year in 2021 with the following endorsement accompanying her nomination: "Her calm, honest and direct approach and sound public health advice have gained the trust of South Australians" (Australian of the Year Awards, 2021).

5.3. Assessing ongoing trust

Whilst the virtuous cycle around *Ti* might characterize earlier elements of the social license for WBE, there is also mounting evidence of disquiet about the authority of government generally in the context of COVID-19 (e.g., Estcourt, 2021) and this raises the prospect of spillover effects to the social license for WBE in the longer term. The challenges presented by the emergence of the OMICRON variant, combined with increased divergence in the approach of governments has also prompted shifts in public sentiment (e.g., Martin, 2021). In addition, WBE runs the risk of being categorized with a range of other surveillance technologies invoked in the response to the pandemic, like QR codes and digital vaccination passports. The fact that some of these technologies have proven problematic (e.g., Koob, 2021) could have spillovers that affect the endurance of trust in WBE.

Following our model in Fig. 3, this would ultimately manifest in communities moving towards *Ti + n* as they consider more cautiously the basis on which they assign trust. The remainder of this section considers the status of the three evaluative components (distributional fairness, procedural fairness, governance capacity) to appraise the work that may need to be done in the future. To make this analysis tractable, we also use the elements of best practice associated with the mining industry, as this is the sector that has the longest history of dealing with social license. This approach realizes eight main tangible activities comprising: (1) monitoring and reporting on social impacts; (2) community participation in monitoring (at least of environmental impacts); (3) including impacts beyond the immediate region; (4) considering impacts on future generations; (5) involving communities in the design of monitoring processes; (6) ensuring use of best monitoring technologies; (7) making information transparent and available, and; (8) ensuring information can be audited. We argue that collectively, these practices represent tangible elements of distributional fairness, procedural fairness and governance capacity, respectively.

5.3.1. Distributional fairness

The perverse distributional impacts of COVID-19 generally are now well known and acknowledged (e.g., Abedi et al., 2021; Patel et al., 2020). These include seemingly unfair economic, social and health consequences and cover multiple geographic scales, spanning international, domestic, regional, and local communities. As community members approach the task of evaluating their individual trust in WBE, there is some possibility that they will bear these broader distributional

issues in mind. WBE has the capacity to both add to and detract from perceptions of distributional fairness.

First, as a technology for monitoring the prevalence of an infectious disease, wastewater monitoring is generally less costly than other methods, like individual testing. One feature of the pandemic has been that clinical testing rates tend to be higher in wealthier districts and these are also generally better equipped for testing. More specifically, conventional detection of the spread of COVID-19 requires individuals to come forward for testing and run the risk of having to later quarantine and thus forego income and be otherwise inconvenienced. This is likely felt more acutely by the poor or those with poorer housing, meaning affluent neighborhoods may undertake more voluntary testing than less affluent areas. In contrast, "Daily sampling of SARS-CoV-2 RNA in wastewater would provide information similar to that from daily random testing of hundreds of individuals in a community, but it is more cost-effective and less invasive" (Larsen and Wigington, 2020).

Second, whilst the case for wastewater-based monitoring on equity grounds is reasonably strong, it is not clear that these distributional issues have been highlighted or discussed with communities at all. There is thus a real risk that any form of monitoring could be associated with distributional concerns, unless proactive engagement with communities on this topic is pursued. In terms of demonstrating distributional fairness through best practices in the mining sector, activities 1, 3 and 4 above are most relevant (i.e. monitoring and reporting on social impacts; including impacts beyond the immediate region; considering impacts on future generations). Arguably, the application of wastewater-based monitoring in Australian jurisdictions has realized very little on any of these fronts, at least relative to the mining industry. There is very little evidence of public discussion about the social net benefits for local communities, the wider society and future generations from WBE. This is not to say that a case does not exist for such benefits; rather limited attention has been given to this topic to date.

5.3.2. Procedural fairness

On the technical front, progress is well underway with the development of protocols around sampling and analysis, especially in an effort to counter the prevalence of false negatives, as occurred in some earlier international applications of WBE for COVID-19 (see Finkel, 2021, p. 4). However, the protocols around the use and communication of WBE results are less developed. In most cases, specialist scientists and laboratory technicians employed by water utilities are trained to undertake technical wastewater analyses; however, it is not clear if the training of this group extends to communicating with the public or government and/or handling health-related data. This raises several practical challenges with implications for perceptions of procedural fairness as well as those relating to governance capacity.

Especially concerning in terms of procedural fairness is the potential for WBE data to manifest in the stigmatization of groups or segments within the community. This risk is greater when the sampling for WBE analysis is sufficiently confined within a sewer network to identify smaller segments of the population (e.g., individual suburb or precinct scale). On the one hand, narrower sampling can assist health officials to trace infection and take early steps to intervene, but on the other hand, the prospect for identifying individuals is increased. Sampling of the sewage from very small, more isolated, and remote communities, or effluent from aircraft or cruise ships would be a case in point. Another example here is the University of Arizona case study where wastewater was monitored at the building (dorm) level during re-entry of students to the campus. Monitoring was able to identify and isolate small numbers of positive infections in individual buildings, preventing larger outbreaks. The study was broadly hailed as a success, though it is not clear whether attention was paid to student consent or ethical considerations/social license to operate (Betancourt et al., 2021).

Whilst the current default position is that the management of such information should be primarily in the domain of public health officials and not wastewater scientists, this does not guarantee that some groups

will not experience or perceive procedural unfairness. In this regard, [Hrudey et al. \(2021\)](#) note that “Investigators and public health units must recognize the ethical importance of having a clear plan on how they intend to deal with the findings of the wastewater surveillance, particularly to avoid creating stigma or exacerbating existing stigma” [emphasis added].

5.3.3. Governance capacity

The [World Health Organisation \(2017\)](#) notes that in the context of public health surveillance, good governance is linked to ethical considerations, even if it is not an ethical principle *per se*. The WHO further recommends that governance mechanisms must “be accountable and open to the public” and that “Transparency requires that policies and procedures for surveillance be communicated clearly and that affected individuals or communities be aware of any decisions concerning them” ([World Health Organisation, 2017](#), p. 22). A community’s capacity to perceive good governance seems likely to thus rely on the processes through which WBE information is communicated.

As it stands, most of this communication is channeled through public health agencies and as noted earlier, this is an appropriate protocol. However, there are at least two elements to this communication flow that warrant consideration. First, data cannot be communicated until the health officials have been able to ascertain the meaning of these data. In an era where uncertainty is common and the pressure is on health agencies to respond rapidly, it will be important that the meaning of data is derived systematically. In this context, [Hrudey et al. \(2021\)](#) note that “because public health officials are less likely to be familiar with the practical limitations of wastewater surveillance, investigators have a duty to fully inform and educate public health officials about the full implications of those limitations”. Second, consideration needs to be given to the communities being ‘communicated to’. The capacity of each community to engage with this type of information will likely be highly variable, but there may be significant rewards to be realized. “Engaging the communities in a COVID wastewater surveillance project can empower citizens to identify and address needs in their communities. This activity poses clear challenges and will not be easy but is important to ensure thoughtful planning before starting a wastewater surveillance initiative” ([Hrudey et al., 2021](#), p. 8488).

Two positive features have emerged around governance. First, the ColoSSoS project has pushed jurisdictions to the point of ensuring that best and most contemporary scientific protocols are employed (see [Finkel, 2021](#), p. 4). Second, the results from wastewater monitoring are now publicly available and regularly updated. For example, in Victoria and New South Wales weekly summaries of outcomes from sewage surveillance sites across these states are presented along with resources to allow laypeople to understand results (see, [NSW Health, 2022](#); Government of Victoria 2022). Nonetheless, it is not clear whether auditing of these data occurs or if processes are in place to capture the use of information by the community. A summary of our assessment of mechanisms to ensure ongoing trust with wastewater monitoring for COVID-19 across all Australian jurisdictions appears in [Table 1](#). This assessment is based on comparisons with the mining sectors that clearly has a more mature history in social license and acknowledges that some individual jurisdictions have made more progress than others on some fronts.

6. Further work and concluding remarks

Our assessment is that WBE is currently enjoying high levels of social license and that communities have not yet been prompted to overtly question the trust they have assigned to WBE. This ‘virtuous’ cycle has been reinforced by the ongoing faith in public health officials and their perceived genuine attempts to manage the more serious phases of the pandemic. However, we have also noted that the continuation of this cycle cannot be assured indefinitely. This could be exacerbated as key personnel change over time. Moreover, if the ambition is to

Table 1

A summary of the status of maintaining social license for wastewater monitoring for COVID-19 in Australian jurisdictions.

Antecedent component	Best practice activity	Status in context of WBE in Australian jurisdictions
Distributional fairness	(1) monitoring and reporting on social impacts;	Requires further attention
	(3) including impacts beyond the immediate region;	Requires further attention
	(4) considering impacts on future generations;	Requires further attention
Procedural fairness	(2) community participation in monitoring (at least of some impacts);	Requires further attention
	(5) involving communities in the design of monitoring processes;	Requires further attention
Governance capacity	(6) ensuring use of best monitoring technologies;	Meets best practice
	(7) making information transparent and available;	Meets best practice
	(8) ensuring information can be audited.	Requires further attention

systematically embed WBE and legitimize its routine use beyond the pandemic, more work is required now to establish this legitimacy ahead of the next public health crisis and to safeguard the ongoing success of routine wastewater monitoring for other applications.

The framework developed here offers a roadmap for this work. Attention to building perceptions of distributional fairness, procedural fairness and governance capacity are three important strands. Reflecting on best practices in mining, where social license has a longer history, reveals gaps on some fronts in the context of wastewater monitoring. However, given the resources for this type of work will always be limited, setting priorities based on those elements that build most trust across different communities would be a helpful starting point. If we accept that the three antecedent elements are potentially substitutable, it would be helpful to understand how different communities make those types of trade-offs. Can an increase in procedural fairness by allowing more participation of the community offset a perceived loss in distributional fairness, for instance? And if so what quantum of change in a specific practice is required to create equivalent trust? In addition, there are important questions about how specific activities or technologies might feed into this framework. For example, how can encryption of data influence elements of the framework and thus drive social license?

There are a variety of well-established methods to gain insights into these types of questions that ultimately would allow for the model in [Fig. 3](#) to be parameterised. Beyond the academic interest however, this type of work could then direct the development of critical institutional settings to maintain the social license of WBE so that we can reliably exploit its full potential for public good.

Credit author statement

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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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