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'Barely keeping the wheels on the trolley': A qualitative study of the New Zealand COVID Tracer App☆

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ABSTRACT

Digital contact tracing apps were developed to help control the spread of COVID-19 but research exploring these apps has underrepresented both 'at-risk' communities and contact tracers. Our study examines perspectives of the New Zealand COVID Tracer app among 53 participants, comprising policy advisors, contact tracers, and Māori, Pacific, and disability stakeholders, underpinned by the theory of social construction of which positions technology within the social context in which it evolves, operates, and is negotiated. Although community stakeholders believed the app helped safeguard communities from COVID-19, the health officials' views on the app's usefulness in contact tracing varied. Participants who oversaw the app's technical development generally perceived it as being more useful, particularly regarding Bluetooth proximity detection, in contrast with contact tracers' perceptions. The findings highlight a disconnection between public sentiment and operational reality in the use of the app and the need for improved collaboration and consultation in future contact tracing responses.

1. Introduction

In the first six months of the COVID-19 pandemic, more than thirty countries employed digital contact tracing (DCT) apps (Mann et al., 2022) – defined as the use of digital applications to identify and/or inform contacts of an infectious case. The rapid spread of COVID-19 exceeded the capacity of many public health agencies to undertake traditional contact tracing methods (Kleinman and Merkel, 2020) and DCT apps offered the potential to increase the speed, specificity, and scalability of contact tracing (Ferretti et al., 2020). Although the findings of empirical evaluations of DCT apps have varied significantly (i.e., Vogt et al., 2022; Kendall et al., 2023), the effectiveness in both modelling and empirical studies relied on high public utilisation (Braithwaite et al., 2020; Mazza et al., 2021). Quantitative surveys have determined that use can be hindered by a range of barriers, such as privacy concerns, digital inequalities, and distrust in governments (see Akinbi et al., 2021; Jalabneh et al., 2021), particularly among groups at greater risk to COVID-19 (Anglemyer et al., 2020), posing the concern that DCT apps could worsen existing inequities.

Seemingly absent from the literature is information about how DCT apps work within a broader ecosystem, involving a complex interplay between technology, diverse sociocultural environments, and the health system. Quantitative surveys cannot capture the contexts and cultural frameworks within which people negotiate using technologies. Qualitative work has tended to examine public perspectives or attitudes towards DCT apps (e.g., Gasteiger et al., 2022; Williams et al., 2021), but, to date, has tended to underrepresent groups of greater risk to COVID-19 (for a notable exception, see O'Donnell et al., 2022), and crucial actors in the DCT app implementation, from policy advisors, service providers, community leaders, and the other (often invisible) end users: contact tracers. The relatively small amount of qualitative research exploring contact tracers' perspectives of DCT has done so in isolation from public end-users (i.e., Chambers et al., 2022; Vogt et al., 2022). National DCT apps offer an opportunity to scrutinize the implementation and utilisation of technology across sectors and environments.

Underpinned by Pinch and Bijker's (1984) social construction of

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technology that recognizes how technology is inextricably linked to the social context in which it evolves, operates, and is negotiated, our research explores diverse perspectives of the national New Zealand COVID Tracer App [NZCTA] used in New Zealand (NZ; also known as Aotearoa or Aotearoa me Te Waipounamu). We undertook focus groups and individual qualitative interviews to examine perspectives of the NZCTA among relevant social groups, comprising policy advisors and contact tracers as well as Māori [the Indigenous New Zealanders], Pacific, and disability stakeholders and community participants (hereafter referred to as stakeholders), including community leaders and service providers. Our study therefore examines the perspectives of stakeholders from community experiencing greater risk from COVID-19 (see Ministry of Health, 2023; Steyn et al., 2020) alongside the perspectives of policy advisors and contact tracers allowing a holistic understanding of the app's functionality, challenges, and implications.

2. The social construction of DCT apps

DCT apps have been described by critical scholars as a 'technofix' (e.g., Kim et al., 2021; Mann et al., 2022) – the positioning of technology as a panacea for complex issues. DCT was viewed as tools to make contact tracing processes faster, more efficient, and scalable (Ferretti et al., 2020) with modelling often based on a high public adoption rate as an underpinning (techno-deterministic) assumption – such as between 56% and 95% for automated systems to contain COVID-19 (Ojokoh et al., 2022). In practice, low public uptake was found to impede the effectiveness of DCT apps in most countries (Chen and Thio, 2021). These findings suggest that DCT "solutions" are not exclusively technical in nature; often necessitating widespread adoption and behavioural changes to be successful in contact tracing COVID-19. Nevertheless, from a social constructivist paradigm, critics who label DCT apps as a technofix may inadvertently succumb to their own oversimplification by generalising national experiences. A principal premise of the theory of social construction of technology is that the working of technology is socially constructed (Bijker, 2010) and thus, is embedded in history, has the potential to change or evolve, and varies between social groups.

National comparative studies have shown how the acceptance of DCT apps diverge across cultural and sociopolitical contexts (e.g., Kostka and Habich-Sobiegalla, 2022; Ojokoh et al., 2022), but have generally overlooked variances in meanings and interpretations across social groups (Bijker, 2010). The theory of social construction of technology posits that each distinct *relevant social group* holds unique interpretations and understandings of a particular technological tool (Pinch and Bijker, 1984) and have respective problems needing to be solved (Bijker, 2010). For instance, marginalised groups (e.g., people from financially poorer socioeconomic groups) and their service providers in Scotland expressed strong support for a DCT app as a contact tracing tool, but economic hardship emerged as a crucial factor impacting the experiences of community members in participating in DCT responses (O'Donnell et al., 2022). This perspective is likely to contrast with that of contact tracers, another group frequently underrepresented in DCT qualitative research. Contact tracers in New South Wales, Australia perceived a DCT app as having limited value compared to traditional contact tracing methods, viewing the app as a source of increased workload (Vogt et al., 2022). Overlooking contact tracers' engagements with DCT apps neglects the pivotal role that local health contexts play in shaping the effectiveness of DCT responses.

In the theory of social construction of technology, the development of technology over time is viewed as a dynamic process characterized by the negotiation among relevant social groups, each embodying a unique interpretation of a technological artifact (Pinch and Bijker, 1984). An inherent issue in comparing national DCT app experiences are differences in both population groups and technological tools used across settings. Consider, for example, the variance in DCT system architectures; the United States and European countries have exhibited heightened concerns regarding privacy and ethical considerations, which led to the adoption of decentralised data storage on personal devices, compared to many Asian countries which favoured data storage on centralised servers (Ojokoh et al., 2022). Significantly, while the social construction of technology recognizes human agency in the negotiation of technology within wider social contexts, technology is still viewed as having the potential to act as a powerful force in reshaping human activities and their assigned meanings (Bijker, 2015). Thus, technology is conceptualised as forming part of a sociotechnical web that needs to be disentangled for understanding.

Finally, the concept of *closure* in the social construction of technology refers to technological artifacts becoming stabilised and 'taken for granted' within a particular society. Closure is the point at which a technological design is no longer subject to significant modification or debate through a process of stabilisation (Bijker, 2010) – becoming an established reality embodying the cultural norms of the society in which it operates. A seminal work that demonstrated this concept was Pinch and Bijker's (1984) analysis of the development of the bicycle that documented how diverse social groups faced unique challenges (such as safety concerns among the elderly and a need for speed among youth) leading to the development of different bicycle designs with varying stability and desirability within the groups. This highlighted how "it is not only engineers … but all relevant social groups that contribute to the social construction of technology" (Bijker et al., 1987, p. 273).

The theory of social construction of technology has found widespread application across diverse fields and technological contexts, underpinning studies on fluorescent lighting (Bijker, 1992), urban stormwater systems (Madsen et al., 2017), user testing (Pinch, 1993), open data use (Lassinantti et al., 2019), the Keelung Port (Shiau and Chuang, 2015), a hospital information system (Wilson and Howcroft, 2005), and a nuclear waste facility (Litmanen, 1996). Each of these studies demonstrate how diverse social constructions and challenges associated with a specific technological artifact can differ across groups. In this sense, the theory serves as a useful methodological tool for understanding how similar technologies might be used or applied differently across contexts or social settings (Wilson and Howcroft, 2005). However, seemingly absent in the literature is an analysis of DCT from this lens, with research tending to focus on technological attributes or barriers to adoption, rather than seeking to understand diverse constructions of the technology. By analyzing the NZCTA through the perspectives of relevant social groups, we provide a nuanced understanding of its adoption and use, which is useful for informing the optimisation of contact tracing efforts in future pandemic responses.

3. Situating the study

On the surface, the public adoption of the NZCTA was promising with 2.1 million app downloads by September 2020 (Blake-Persen, 2020), accounting for a substantial portion of NZ's 5.1 million population. Yet DCT app downloads do not necessarily reflect usage. For example, many DCT apps require active participation from users to scan location based QR code systems. In NZ, even during outbreaks, a maximum of 35% of registered users engaged in at least one scanning activity per day (Howell and Potgieter, 2022). The NZCTA was released on May 20, 2020 for smartphones via official app stores. It provided the functionality to update an individual's contact details and to scan QR codes for location tracking in contact tracing. QR codes contained location information such as the address and a unique location identifier, creating a "digital diary". Entries were automatically removed after 60 days, with users having the discretion to share their data with contact tracers upon request. Upon contracting COVID-19, a case could upload their digital diary to contact tracers if prompted to do so during their case investigation. Contact tracers could then decide whether locations were pushed as notifications to any other people scanning at the same location, at the same time as the case. In August 2020, authorities made it mandatory for businesses to display QR code posters for contact tracing purposes and in August 2021, record-keeping through QR code

scanning or manual recording became obligatory when entering events and business locations.

Bluetooth proximity detection was added to the app in December 2020, which adopted the Apple/Google Exposure Notification Framework. This system used Bluetooth to exchange digital contact events with other enabled smartphones, involving wireless and passive exchange of (anonymous) identification keys between devices if this app function was enabled by users. Should a user test positive, their anonymous 'keys' could be uploaded and sent to devices of users who may have been exposed notifying those people that they had been in close proximity of someone who had tested positive to COVID-19. Overall, 2.4 million devices participated in the Bluetooth function, accounting for 62% of the population aged over 15 years (Chambers et al., 2024). On March 23, 2022, the requirement for QR code scanning was lifted, but Bluetooth Tracing technology continued to operate. Full descriptions of these tools and a timeline of key developments have been outlined elsewhere (see Chambers et al., 2024).

Research examining public perspectives of the NZCTA has identified uptake barriers in relation to the perceived risk of contracting COVID-19, smartphone accessibility and usage, and to a lesser degree, privacy concerns (i.e., Ali and Dang, 2022; Gasteiger et al., 2022; Tretiakov and Hunter, 2021). However, Māori, Pacific, and disabled people[1] are underrepresented in this research – three priority communities in Aotearoa as outlined in the following section. Furthermore, the only published study that we could locate examining contact tracers' perspectives of DCT in NZ after the release of the NZCTA reported on three focus groups undertaken in late 2020 by some members of our research team *[citation removed for peer review]*. Contact tracers relayed concerns related to the potential replacement of manual processes unsuitable for automation, potentially overburdening the system and yielding unproven or limited benefits. Given the study's restricted scope and the subsequent advancements both in the technology (with the introduction of Bluetooth proximity detection) and the broader pandemic response (a complete shift of all contact tracing to digital approaches in February 2022), a more comprehensive inquiry involving contact tracers and a range of community stakeholders was deemed necessary.

4. Methodology and methods

4.1. The relevant social groups

The social construction of technology involves reconstructing technology interpretations through the eyes of relevant social groups, analyzing conflicts they generate, and connecting them to design characteristics, grounded in a premise that technology and human behaviour are intertwined and influence one another (Pinch and Bijker, 1984). Understanding the application of DCT apps demands such multi-perspective analyses, as the effectiveness relies on both the technological design and the actions of diverse actors. A high uptake by the public is required for DCT to be useful for contact tracers (Braithwaite et al., 2020), while simultaneously, the appropriate use of DCT data by contact tracers is needed in contact tracing the public (Vogt et al., 2022). Similar dynamics exist within the contact tracing sector. The policy arm of the national public health sector involved in the contact tracing response [hereafter referred to as "National-CT"], including a digital team who oversaw NZCTA's technical development, relied on individuals in regional public health units [hereafter, "Local-CT"] who perform operational engagements in contact tracing COVID-19. A rapid research report during the pandemic emphasized the necessity of collaboration between the National-CT and Local-CT in developing and implementing DCT approaches (Allen + Clarke, 2020).

Beyond these relevant social groups within the contact tracing sector, we identified three priority community groups in the public update of DCT in NZ: Māori, Pacific, and disabled people. Statistically, these groups face a greater risk of severe illness from COVID-19 compared to the general population (Ministry of Health, 2023; Steyn et al., 2020). Furthermore, with Māori historically underserved in the healthcare sector, the Government are obliged to ensure their adequate representation in decision-making processes under Te Tiriti o Waitangi (Waitangi Tribunal, 2021), the constitutional document between Māori and the Crown in NZ. The significance of these groups was acknowledged by the former Minister for COVID-19 Response, Ayesha Verrall (2022), who stated that the Ministry has adopted "an 'equity-first' approach to its COVID-19 response, underpinned by the Government's commitment to Te Tiriti o Waitangi … This approach includes recognising the disproportionate impact of COVID-19 on our most vulnerable populations, including Māori, Pasifika, and disabled people" (p. 6). However, Māori, Pacific, and disabled people also have reduced access to information and communication technologies (Digital Inclusion Research Group, 2017), posing a challenge in the DCT response, whereby those largely overlooked in other technological developments are pivotal for the success of DCT responses.

4.2. Methods

Study procedures were approved by the *[ethics committee name removed for peer review]* and all participants provided informed consent. The focus groups and interviews were undertaken between February and July 2023 through a mixture of Zoom and in-person formats and were, on average, 90-min long. The focus group for the National-CTs and Local-CTs concentrated on NZ COVID-Tracer data utilisation, its effectiveness and barriers to DCT data utilisation. Similar queries were tailored for community stakeholders, examining barriers and facilitators related to the NZ COVID-Tracer app's use throughout the pandemic. For the recruitment of National-CTs and Local-CTs, managers were emailed information about the study, and they collaborated in sending out the invitation to CT staff on behalf of the research team. In accordance with Māori and disability research guidelines (e.g., Hudson et al., 2010; National Ethics Advisory Committee, 2021), six community leaders in the Māori and disability sectors were informally consulted on the engagements with community stakeholders (we were unable to engage with Pacific leaders at this time). The recruitment was informed by stakeholder mapping, community consultations, and snowball sampling. In cases of scheduling conflicts, alternative sessions or interviews were offered.

Six focus groups (a combined total of 30 participants) and four individual interviews were undertaken, comprising Māori (n = 10), Pacific (n = 15), and disability (n = 11) stakeholders (two participants identified by two stakeholder groups), including representatives of eight disability, six Māori, and four Pacific organisations, 15 members of Māori and Pacific churches (as churches were central in initial COVID-19 clusters in Auckland), eight people with a lived experience of an impairment or who identified as disabled, six researchers, and a range of community leaders. The demographic information is provided in Table 1.

Interviews and focus group sessions were transcribed verbatim, anonymized with participants being assigned pseudonyms. The social construction of technology entails examining and comparing social groups' perspectives on technology without assuming a preconceived preference for one relevant social group over another (Bijker, 2010). The focus is on understanding the social processes within groups rather than describing the technological product. To achieve this, we adopted an

[1] *'Disabled people'* is commonly used in the public sector in NZ for people with lived experience of an impairment or identifying as disabled (e.g., Office for Disability Issues, 2016).

Table 1
Demographics of relevant social groups.

Demographic	Community stakeholders n(%) n = 34	Contact tracers n (%) n = 19	Total n(%) n = 53
Age			
18-34	2(5.9)	4(21.1)	6(11.3)
35-54	16(47.1)	7(36.8)	23(43,4)
55+	10(29.4)	1(5.3)	11(20.8)
Missing	6(17.6)	7(36.8)	13(24.5)
Gender			
Male	16(47.1)	8(42.1)	24(45.3)
Female	18(52.9)	8(42.1)	26(49.1)
Missing	0(0)	3(15.8)	3(5.6)
Ethnicity[a]			
Māori	9(26.5)	1(5.3)	10(18.9)
Pacific	16(47.1)	0(0)	16(30.2)
Pākehā/ European	9(26.5)	9(47.4)	18(34.0)
Other	1(2.9)	2(10.5)	3(5.7)
Missing	0(0)	7(36.8)	7(13.2)

[a] Participants could identify as multiple ethnicities, so figures exceed the number of participants.

inductive approach to reflexive thematic analysis (i.e., Braun and Clarke, 2019, 2021; Byrne, 2022), which is theoretically flexible and interpretative, allowing for the identification of themes as "patterns of shared meaning" (Braun and Clarke, 2021, p. 331). The process commenced by re-reading transcripts, followed by recognising initial codes emanating from participants' responses, and organising these codes into potential themes (for further information about this process, see Braun and Clarke, 2019, 2021). These were themes subsequently refined, defined, and named. An experienced qualitative researcher conducted the analysis. Three members of the research team each checked 1–2 coded transcripts and there was reporting and discussion within the research team. Tentative findings were shared with participants to gather feedback.

Six themes were identified that were categorised under two umbrella concepts: *Using the App for Contact Tracing* and *Communicating Across Diversity*. The thematic findings do, in part, connect to each other. At times this was encountered in the coding, for instance, aspects of the divergent views between the National-CTs and Local-CTs regarding 'Bluetooth proximity detection' (Theme 3) was originally coded under 'Utility in contact tracing' (Theme 1), but in the iterative analysis process it was deemed that this was emphasized and expressed differently enough to be a distinct theme in its own right. Furthermore, the themes also conceptually intertwine, such as we show in the last theme how difficulties in communicating across diversity (the second umbrella concept) contributed to challenges in using the app for contact tracing (the first umbrella concept). Altogether, the six themes outline the diverse constructions and experiences of the NZCTA.

5. Findings

5.1. Using the app for contact tracing

In exploring the application of the NZCTA for contact tracing we revealed a disconnection between public sentiment and operational reality. Many community stakeholders expressed the belief that the app contributed to keeping their communities safe from COVID-19 through contact tracing with Marama [Māori-sector] stating, "If you … have this [app] on your phone and if you learn how to do it and become technology-orientated … it saves our whakapapa [genealogy/lineage]." National-CTs in the Digital Team constructed the app as facilitating a paradigm shift in health information governance to position consumers as in charge of their information. For instance, Richard emphasized that, "It was quite transformational. Having this [app] … put the power into the consumer or the patients' hands … Incredibly powerful." However, some Local-CTs reported reservations about the technology's effectiveness in the realm of contact tracing, particularly Bluetooth proximity detection. As Lily reflected, "[I] struggled to see the utility of that app … It was a good aid memoir … It wasn't a contact tracing answer." This was echoed by Derrek [National-CT], who stated, "The value of it was fairly low in terms of utilising it for contact tracing", raising questions about its actual efficacy, its role within the pandemic response, and ethical implications on public transparency and consent.

These varied perspectives are developed in the following three themes. In the first theme, we examine the perceived utility of the app in contact tracing. We then explore contrasting perceptions of the app's decentralised architecture, which the Digital Team advocated for, but other contact tracers regarded as inefficient in terms of contact tracing. Finally, we close with contrasting views of Bluetooth proximity detection. The three themes highlight an intricate negotiation between technological feasibility, privacy concerns, and public health needs in developing DCT.

5.1.1. Theme 1. Utility in contact tracing

The contact tracers expressed varied views about the perceived utility of the app. Anne [National-CT] described this as "debatable", while the Digital Team felt that it "absolutely did" [Deborah] help in contact tracing. Derrek [National-CT] explained that the app "probably adds like the 20%" more information that otherwise would not be retrieved about locations where users visited, while other contact tracers felt that the tracing mechanism could record both entry and exit times from premises to "capture more accurate data" [Daniel, Local-CT]. Lily [Local-CT] suggested that public perspectives may be: "a little bit overhyped … It should have been seen as more of an aid as opposed to a solution which I think is partly to do with how it was framed and kind of sold to the public". Her positioning of the app as an "aid" implies a place for the app in supplementing, rather than replacing, existing contact tracing practices.

Lily's perception was reinforced by other contact tracers, with Sarah [Local-CT] stating: "It's a tool that we had. I mean, ugh, it depends on the user." Sarah's observation, that the user's adoption influenced the app's utility in aiding contact tracing, emerged as a key thread expressed across many contact tracers' narratives often in interconnection to the community infection rate and the phase of the contact tracing response. Derrek [National-CT] further explained that in the "elimination [phase] … then its value is high, but usage is incredibly low, so of little value … When you moved into kind of Omicron stuff it … became far less valuable because you've got widespread community transmission." This points to contact tracers' experiences being contextually embedded and, therefore, the importance of aligning pandemic responses with DCT efforts to maximize efficacy.

However, community stakeholders generally considered the app to be an effective contact tracing tool. Māori and Pacific stakeholders particularly emphasized a widespread willingness to adapt social practices in using the app and help those with low digital literacy, access to smartphones and English fluency in its adoption. In this realm, many stakeholders constructed the app as a form of security or safety from COVID-19, stating: "The COVID Tracer App kind of keeps the community safe" [Adelyn, Pacific-sector], "we all felt a sense of security" [Scott, Māori-sector], "people from the disability community … knew that the app, it was useful" [Dilara, Disability-sector], and "It's something about safety … That is paramount … So, I have to do it" [Aisake, Pacific-sector]. A couple stakeholders queried this construction, with Christine [Māori-sector] stating, "It was almost a false security because [while] I may have been following those rules … not everybody else was", but the predominant view was that the app facilitated effective contact tracing, "Because … that's what the COVID Tracer App is, to COVID trace!" [Emma, Māori-sector].

5.1.2. Theme 2. The decentralised architecture

In addition to assisting in contact tracing, the Digital Team felt that the app positioned the public in control of their information through the

decentralised architecture. Richard explained: "The control is in … the individual's hand … Whereas a lot of the contact tracing is sort of by design, overtly privacy invasive." His statement emphasizes agency afforded by the app; allowing users to voluntarily engage in contact tracing through their devices, where the information is also stored, facilitating personal choice and control, and contrasting with traditional contact tracing. Benefits expressed about the decentralised architecture included safeguarding data – "If you don't have it [data], you can't lose it" [Henry], public acceptance and, most strongly emphasized, a sentiment of ethical responsibility and intentionality. As Deborah stated: "We could have done a much more invasive solution and people largely would have accepted it, but it would have been the wrong thing to do."

Contact tracers outside of the Digital Team did not share Deborah's technological solutionism and expressed scepticism about the practical efficacy of this decentralised approach. While systems became more efficient as the pandemic progressed, they pointed to ways the decentralised architecture could introduce inefficiencies stemming from manual processes required to facilitate behaviour change. For instance, when individuals received an exposure alert on the app, they needed to call Healthline (a publicly funded phone service that provides health advice), following which, Healthline staff would manually input the information into a database for the National-CT. Subsequently, a different subset of Healthline staff would conduct the follow-up. This multi-step process introduced possible information inaccuracies and gaps, and related barriers to behaviour change among contacts. Contact tracers also reported time consuming challenges with QR location tracking regarding "difficulty chasing up and finding the locations" [Liam, Local-CT]. However, when asked if a centralised system would be more useful, Derrek [National-CT] responded: "Well possibly, but … App Store privacy stuff might have trumped it anyway"– revealing a design focus on public accessibility through the utilisation of dominant platforms but also the influence from the technology on contact tracing processes.

Adding to this complexity was the communication gap among members of the public with some Māori and Pacific stakeholders indicating low awareness of the decentralised nature of the app that was often tied to distrust, stating "One whānau [family] member … hated the idea of being tracked … their data stored with the government agency" [Sophia, Māori-sector] and described "… that whole mentality of 'I don't want the state knowing where I was'" [Adelyn, Pacific-sector]. National-CTs discussed misconceptions around the decentralised architecture with Olivia stating, "A lot of the public always thought that we could, you know, see more of their information", reinforcing this communication gap, while Anne responded that this included: "Senior government staff …. People thought that by using the app we automatically had access to that person's details", highlighting sector disconnection that could hinder cohesive pandemic responses.

5.1.3. Theme 3. Bluetooth proximity detection

The divergence of views was exemplified through the Bluetooth proximity detection functionality. National-CTs expressed frustration at the low use of Bluetooth data among Local-CTs "… not seeing the value of Bluetooth" [Derrek], while Local-CTs explained that: "It wasn't helpful to us at all" [Paul] and recalled instances where they felt it was inaccurate. National-CTs attributed various possible reasons for this low uptake among Local-CTs, particularly a low awareness and understanding of the function and, among some of the Digital Team as stemming from: an "anti-technology bias" [Andrew] and a " … philosophical … disagreement with the technology." [Henry]. This example illustrates the implication of diverging views in the health sector, materialised through the app's suboptimal utilisation, a situation unseen by the public. Although community stakeholders had more varied uptake of this function compared to QR location tracking, the motivation behind their uptake was grounded in the concept that it "gave you another layer of security and safety" [James, Māori-sector] as Greg [Disability-sector] expressed: "Bluetooth … for me I felt some protection from, from that".

5.2. Communicating across diversity

> *Derrek [National-CT]: It raised COVID up. It created visibility. It created, yeah, engagement with people. And irrespective if the app was useful or not useful [for contact tracing], it created that conversation and thinking, which was incredibly valuable for us because it put it into the public psyche of what was going on.*

Derrek expressed that the app had limited direct usefulness in contact tracing processes but then turned to its indirect value in creating a public discourse and "psyche" about the pandemic. His statement reflects a broader context where communication processes (both surrounding and within the app) played a foundational role in shaping many of its successes and constraints. As we discuss in the following theme, the app's value extended beyond direct contact tracing processes, becoming a tool for mass communication through (mandated for an extended time) the publishing of QR code posters at every public location in NZ, exposure alerts and, as Derrek alluded, its very existence could serve as an influential medium of communication, contributing to a wide public awareness of COVID-19 that exceeds its functional purpose. However, these communication media were not experienced equally and for the stakeholders, the underserved were often clients, whānau [family], and members of their communities. The next theme explores the engagement of priority communities in DCT efforts. Yet unobserved by community stakeholders was the "pressurized environment" [Anne, National-CT] experienced by contact tracers, which formed the backdrop of sector (mis)communication discussed in the final theme.

5.2.1. Theme 4. A tool for mass communication

Contact tracers depicted the app as a "tool for mass communication" [Olivia, National-CT], stating: "I don't know if it helped with contact tracing, but I think it helped with getting messages out to a large number of people." [Anne, National-CT] A prominent communicative feature of the app was its exposure alerts, discussed across the participant groups. This could communicate public health measures – "a brilliant way to, to get a message through" [Amanda, Local-CT] – and play a crucial role in instilling a sense of reassurance, making the public "feel comforted" [Daniel, Local-CT] in the pandemic response, as Iris [Disability-sector] expressed: "people were reassured, especially when people were getting alerts". Nonetheless, a concern was voiced by disability stakeholders that alerts "didn't give enough information" [Elena], being "not specific enough" [Beth] – a point that Deborah [Digital Team] acknowledged, explaining that the time offset "only gives you a UTC [Coordinated Universal Time] Day … so we can't tell people which day they were exposed". This, again, reveals a technological influence on shaping the nation's contact tracing infrastructure, in this case impacting the ability to provide detailed individual level communications about COVID-19 exposure times.

Nevertheless, some contact tracers suggested that the app's digital communication extended beyond the functionality of these alerts, describing how its mere presence could function as an implicit means of communication. Daniel [Local-CT] maintained that through QR scanning: "you're essentially forced everywhere you go to be given a reminder that there's a pandemic … Subconsciously, at the very least, [it] will give you a, a prompt that maybe go and get a vaccine." His statement delves into potential psychological effects of the app, whereby its use could influence behaviour – in his example, being a "prompt" to get vaccinated for COVID-19. This "flow on effect" [Anne, National-CT] was discussed by other contact tracers who felt that the app influenced the public to "think about the fact that they needed to remember where they've been and … who they've been in contact with" [Henry, Digital Team] and undertake preventative precautions as "when you're going to a supermarket … it's on your mind" [Ben, Local-CT]. This view was not

expressed as strongly by community stakeholders, but from some contact tracers' perspectives, the existence of the app: "contributed towards the social, that … level of discourse around … how the individual things that we can do can support the response" [Henry], alluding to an interplay between technology, cognitive processes, and public health behaviours.

5.2.2. Theme 5. Community engagement

Contact tracers, in general, gave comparatively less emphasis on the importance of community engagement than the community stakeholders. Anne [National-CT] described how the rapid development limited the opportunity for meaningful engagement with diverse communities, but also indicated that sector disconnection restricted the interface inclusivity, stating: "We pushed and pushed and pushed for different languages the whole way … We were always just told it was too hard, too long, too difficult." Henry [Digital Team] reflected on an interaction with a representative from a blind and low vision association following the app's release:

> *I'll never forget … Trying to explain all the accessibility features … And [having] them say, 'well, that's fine, but I can't see a poster stuck to the wall, because I'm blind' … My immediate reaction to that was defensive: 'well, it's not designed for you then, is it?' … And having that person then quite fairly say, 'well, this is my life … My entire existence. I get told to do something by the Prime Minister or by the Minister of Health … that downloading this app is going to save my life and I can't use it, so what do we do about that?'*

This excerpt offers insight into the intersection of technological design, accessibility, and lived experiences of people with disabilities. Henry's initial defensive reaction reflects a challenge and common oversight in technology development – the tendency to prioritize the needs of the majority while excluding a marginalised minority who, in the context of COVID-19, were (and are) at greater risk of more severe illness from infection.

While the app facilitated widespread digital communication, community stakeholders drew attention to those underserved – predominantly kaumātua [Māori elders], elderly, migrants with low English fluency, and disabled people, describing how "having a phone was a barrier. Some people didn't have phones" [Adelyn, Pacific-sector] and "if you're in a wheelchair and you don't have the ability to lift your arm up, it's pretty difficult to scan" [Alice, Disability-sector] and how this resulted in some community members staying home during the pandemic. Community stakeholders proposed recommendations to improve the app's accessibility, including incorporating haptic feedback, colour contrast, read aloud functions, images, cultural branding, diverse language options, and another location tracking method for those who found posters difficult to locate or scan. The absence of these features signals that the app was not designed around the needs of those at greatest risk of poor outcomes from COVID-19 infection, and many community stakeholders stressed that further engagement with priority communities is needed, stating: "let us be there to sit beside you and we will develop it together because we can help you understand how our people will be able to [use it] or will engage" [Christine, Māori-sector] and "when something is going to be developed … include disabled people … Get it right from the design … Not like: 'oh … we've done this, now you tell me if it doesn't work or not'" [Elena, Disability-sector]. Elena's statement aligns with Iris's [Disability-sector] view that people with disabilities were an "afterthought" in the app design, highlighting the importance of collaborative decision-making and co-creation to ensure that technologies genuinely cater to community needs.

5.2.3. Theme 6. Sector communication

> *Public health professionals weren't really close to the process … Everyone was sort of like: 'Oh my gosh. You've got an app that's going to make everything amazing!' … Without really understanding … and thinking through 'is this going to do for us what we think it's going to do?' [Olivia, National-CT]*

Olivia and other contact tracers also perceived a lack of meaningful involvement in the app's development. In the above excerpt, she portrays the app as a technofix in which the enthusiasm surrounding the development overshadowed its efficacy assessment with contact tracers. Her statement was echoed by others who stated: "it's the nature of just having an app as the kind of solution for all of world's problems" [Lily, Local-CT] and "It was very much a digitally led project with assumed knowledge and assumed understanding of what contact tracing was." [Derrek, National-CT] However, Henry [Digital Team] recalled challenges in effectively engaging with contact tracers, stating: "You couldn't … sit down with the contact tracing team for half an hour and say, 'Hey, what would be useful for you?' Because we're so busy trying to contact trace."

Consistent with Henry's statement, contact tracers relayed how sector communication challenges existed within an environment characterized by heavy workloads, burnout, and stress, being "extremely busy … barely keeping the wheels on the trolley" [Emerson, Local-CT]. The difficulties related to Bluetooth proximity detection illustrate how this environment could influence sector engagement and result in suboptimal data use: Anne [National-CT] described how their communication of this functionality was "Very much like, 'okay, we've written this thing. It's 27-pages long, cos we don't know how to explain it any shorter, but ugh here it is just … believe it'", while Lily [Local-CT] recalled "Trying to make time to read it [this document] but always finding it a little bit too hard and a little bit too complex". The Digital Team described pressures to promptly deploy the app due to the urgency of the pandemic, stating: "Government was lagging behind, so it was like 'get it done … get something out there'" [Ben] and "We were kind of just doing what we could to get something out the door to start with" [Henry], revealing critical tensions between the rapid implementation and ensuring functionality and user acceptance.

6. Discussion

The NZCTA has been promoted as an essential part of an effective pandemic response in NZ (see Robert, 2020; Tretiakov and Hunter, 2021) where citizens were called to "Unite against Covid" in public health interventions (Wilson, 2020). This framing was reinforced by community stakeholders in our research who supported the uptake of the NZCTA, arising from a collective construction that it is a form of (lifesaving) protection from COVID-19 and contributes to the safety of their communities, with Māori and Pacific stakeholders particularly emphasising their responsibility to adapt social practices by actively using the app and helping others to do so. Contact tracers echoed the need for high public adoption of the NZCTA, aligning with scholarly discussions about the dependence on widespread public DCT use to successfully contain COVID-19 (e.g., Braithwaite et al., 2020; Mazza et al., 2021). This emphasis on public adoption, while important, can overshadow a critical issue: the potential to exclude groups at the greatest risk of poor COVID-19 outcomes, including those with disabilities, limited smartphone accessibility, and low English or digital literacy. This situation inadvertently places the onus on the public for DCT success without providing the necessary tools for their adoption, such as disability accessible options and smartphones. Erased are the lived experiences of individuals who were unable to participate in visible acts of 'unity' through QR code scanning – those the app was "not designed for" (as a digital team member stated).

Significantly, the prevailing discourse connecting public adoption with DCT success represents only a partial perspective of the complex landscape of the NZCTA, as illustrated in Fig. 1. There is a notable absence in scholarly and public debates regarding how contact tracers use data from DCT apps to assist in contact tracing (with few exceptions, e.g., Vogt et al., 2022). In examining diverse perspectives of the NZCTA,

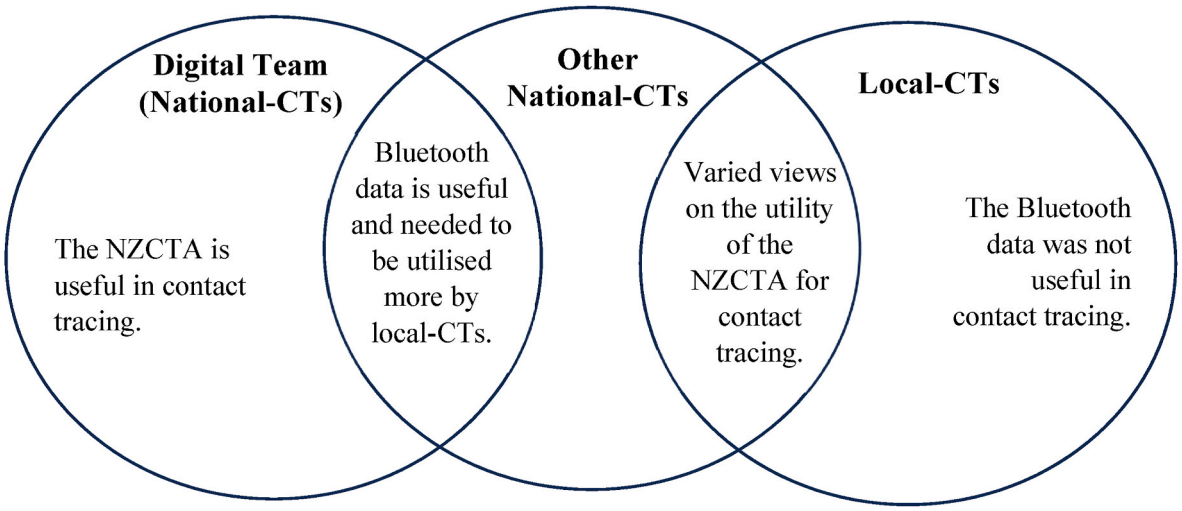

Fig. 1. Diverse perspectives of the NZCTA's utility among contact tracers.

we revealed competing constructions that are obscured in public discourses. The digital team who oversaw the development of the NZCTA thought the app "absolutely did" help in contact tracing and positioned consumers in charge of their information through the decentralised system architecture (although the communication gap regarding this architecture among some community stakeholders raises questions about its public impact). However, some contact tracers revealed reservations about the technology's utility in contact tracing viewing it as an "aide" secondary to existing contact tracing practices. To understand these reservations, examining participant experiences is insightful: Local-CTs pointed out technological limitations affecting their tasks, such as inefficiencies from the decentralised architecture, some digital team members who oversaw the development of the NZCTA suspected a technological bias among Local-CTs, while a consistent description across the contact tracers was of sector 'disconnect' and insufficient engagement between Local-CTs and National-CTs.

The contact tracers' varied perspectives highlight the importance of addressing operational challenges alongside broader issues like sector disconnection and overburdened work conditions during the pandemic. This variance was particularly pronounced regarding Bluetooth proximity detection, where reservations manifested in the low use of Bluetooth data by Local-CTs as we also have revealed in quantitative analyses (citation removed for peer review), demonstrating the implication of diverging views of technological tools in the health sector.

Our study supports the premise that distinct social groups have unique, and sometimes conflicting, interpretations of an emerging technological tool (Pinch and Bijker, 1984), as observed in other contexts (e.g., Bijker, 1992; Pinch, 1993; Pinch and Bijker, 1984; Wilson and Howcroft, 2005), uncovering a web of perspectives and concerns. Underlying participant descriptions was the NZCTA's influence on human behaviour: acts of the contact tracing process included public-initiated engagements with Healthline staff following digital exposure alerts and contact tracers locating QR code addresses. For some contact tracers, the app evolved into a tool for mass communication with its very existence serving as an influential medium of communication about public health measures. Scanning QR codes became a normalize practice that could influence behaviour within the pandemic response, reinforcing its status as a sociotechnical artifact.

The varied constructions demonstrate the importance of analysing diverse perspectives when introducing digital tools. Consider, for example, debates surrounding privacy concerns and the collection and storage of DCT data. Tretiakov and Hunter (2021) suggested introducing options to provide faster access to more detailed information to assist contact tracing based on a finding that privacy concerns had limited impact on the public adoption of the NZCTA. Privacy was also not a central concern among some community stakeholders we spoke to, although there were instances relayed where this could interplay with distrust in hindering the uptake among marginalised community members. Yet discussions with National-CTs revealed other justifications for data being collected and stored through a decentralised architecture, including the adherence to App Store privacy regulations. The influence of these regulations on the nation's contact tracing is noteworthy (for a discussion on related ethical issues, see Mann et al., 2022), as the decentralised architecture introduced inefficiencies to manual processes and could provide contact tracers with incomplete information required to facilitate behavioural change among contacts. Nevertheless, this example shows how examining diverse perspectives offers a more in-depth account regarding privacy considerations and the development of health technologies.

However, there are distinctions in DCTs that are undertheorized in foundational literature on the social construction of technology. Unlike the bicycle, where user preferences regarding aesthetics, convenience, and speed influenced its evolution into various forms (Pinch and Bijker, 1984), the NZCTA was implemented, under a situation of urgency, by the Ministry of Health. This may exacerbate power imbalances between the producers of the technology and the public end-users in the development of DCT, particularly when its use for premises entry was mandated by the government. Nevertheless, its adoption still relied on public trust. In our research, participants noted that some marginalised community members distrusted the government in line with previous research (Elers and Dutta, 2023), hampering adoption, but broad trust in the NZCTA and support for its uptake was identified. NZ has high levels of trust in the government compared to other OECD countries (OECD, 2023), which was found to intensify during the pandemic (Chapple and Prickett, 2022).

When considering the eventual discontinuation of the NZCTA in 2023 due to shifts in the strategy for containing COVID-19 (see Chambers et al., 2022), it is likely that the pandemic's unique circumstances disrupted conventional decision-making processes. If NZCTA use had continued, there might have been opportunities to incorporate accessibility changes to address community stakeholders' concerns, aligning with the principles of the social construction of technology. However, it is improbable that community stakeholders could have influenced data usage, as they were not explicitly exposed to the challenges faced by contact tracers, demonstrating how information inequity impacts technological development in healthcare contexts. This aligns with criticisms of the theory of social construction of technology for not adequately considering structural and cultural influencers within

technological design (Klein and Kleinman, 2002) and further marginalising those who do not have a voice in this process – articulated by Winner (1993) as a "problem of elitism" (p. 370). Ethical concerns pertaining to public engagement, transparency, and consent arise from the conflict between contact tracers' varying viewpoints regarding the efficacy of the NZCTA in contact tracing (particularly Bluetooth proximity detection) and the community stakeholders' understandings.

Furthermore, both Local-CTs and community stakeholders voiced discontent over their perceived exclusion from decision-making processes in the NZCTA's design, which impacted its usability. At a structural level, the exclusion of the community groups from decision-making on matters that directly impact them conflicts with principles outlined in the United Nations (2006) Convention on the Rights of Persons with Disabilities and Te Tiriti o Waitangi. At an individual level, community stakeholders recalled how contact tracing requirements led certain elderly and disabled people to feel compelled to remain confined to their homes, illustrating how issues from the app's accessibility surpassed the domain of contact tracing through their isolation and exclusion from wider society. While Bijker et al. (1987) concept of a *technological frame* recognizes both material and non-material structures influencing socio-technical design, we, in line with others, contend that comprehending the cultural and structural dynamics that shape technological development necessitates the inclusion of marginalised groups' perspectives within the analytical framework (e.g., Winner, 1993; Klein and Kleinman, 2002). We further call for inclusive and equitable processes in shaping technological responses in the context of public health to ensure that voices of marginalised communities are not only heard but also play a central role in the development.

Our findings additionally highlight the importance of gaining a comprehensive understanding of the needs and experiences of health officials (in our study, contact tracers), and addressing sector disconnection for effective public health technologies. We note how scholars have advocated for involving end users in technological design (e.g., de Graaf et al., 2018), which can enhance a technology's adoption and utility, but our findings also reveal a need to explore alternative approaches before developing digital tools for public health. There was a perception among some contact tracers that the NZCTA was a form of technofix, which overshadowed critical efficacy assessments and additional tools that could capture more accurate data, such as recording entry and exit times in the QR scanning functionality. Some expressed that the NZCTA had little value in contact tracing. From our findings, we offer the following recommendations for policy makers and professionals. These are focused on DCT, but the principles can potentially be applied to many other public health technologies. We recommend.

1. Undertaking proactive planning and engagement with diverse stakeholder groups now to ensure that the needs and perspectives of relevant social groups are incorporated into future pandemic responses. Greater collaboration with priority communities would uphold Te Tiriti o Waitangi and improve accessibility and participation in DCT tools.
2. Engaging Local-CTs the development of DCT tools. Failure to convince contact tracers of the utility of DCT substantially reduced the potential impact of NZCTA.
3. Implementing future DCT tools with as few manual processes as possible for users and contact tracers alike. Manual steps, particularly with the QR-code system, increased workloads for contact tracers and the likelihood of data being under-utilised.
4. Developing and testing DCT tools during non-pandemic periods so that the systems and technology can be scaled-up when needed.

7. Study limitations

We have cautioned against generalising DCT app experiences across different countries. There are contextual differences in considering the NZCTA compared to other technologies, such as in the technological tools used, population differences, and the pandemic responses. Furthermore, in our data collection, variations in focus group sizes (between two and eight participants but five on average) and data integration from interviews pose challenges in the representation of participant perspectives, but this approach was chosen due to practical considerations aligned with participants' availability and needs. Thus, while providing valuable insights, the context-specific nature of this research should be considered when applying its findings to broader populations or settings.

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Ethics approval statement

All study procedures were approved by the University of Otago Human Ethics Committee (HE20/010).

Patient consent statement

All participants completed informed consent processes.

CRediT authorship contribution statement

Phoebe Elers: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Sarah Derrett:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Tepora Emery:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Tim Chambers:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

There are no conflicts of interest to disclose.

Data availability

The data that has been used is confidential.

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