Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Factors impacting the use of the NZ COVID Tracer application in New Zealand"

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ABSTRACT

The COVID-19 pandemic has clearly created devastating damage on world economics and public health. This project identifies key concerns of end-users toward the NZ COVID-19 contact tracing app in New Zealand. The key research objective in this study is to understand the usage behaviour towards the mobile application NZ COVID-19 Tracer used for contact tracing purposes. Secondly, the study explores the reasons for using the contact tracing app. Thirdly, it examines the relationship between usage behaviour of the NZ-COVID Tracer app with age, the user's perceived health, attitude towards COVID-19, whether family or friends are infected by COVID-19, trust in maintaining social distancing, trust in data privacy, smartphone usage and the media's role in motivating people to use this app. Consequently, understanding these issues and challenges could help improve the usage of this contact tracing app, which in turn would contribute to better public health outcomes in disease management and containment.

Findings of the study reveals that age, smartphone usage behaviour, and trust in privacy data protection from the app provider has a statistically significant relationship on usage behaviour of the NZ COVID Tracer app. Self-perceived health status and attitudes towards the COVID-19 pandemic did not have a significant relationship on NZ COVID Tracer app usage behaviour. While social media, such as Facebook, has been shown to be the most popular source of news for COVID-19 among New Zealanders, it is television that acted as a motivational tool to encourage people to use the contact tracing mobile application and to practice other measures to help protect against the COVID-19 pandemic.

1. Background

The COVID-19 outbreak has had the greatest impact on public health this century (Altmann et al., 2020; Dong & Bouey, 2020). The pandemic has forced many nations globally to enter lockdown periods, resulting in massive economic instability and social stigma (Bambra et al., 2020; Stratton, 2020). Since COVID-19 is a novel respiratory coronavirus emerging from late 2019, we have relatively little known information about this virus. However, we can only rely on the previous coronavirus strains, the Middle East Respiratory Syndrome (MERS) related coronavirus and the Severe Acute Respiratory Syndrome (SARS) related coronavirus, to study the transmission and infection characteristics of COVID-19. One of the measures to contain the COVID-19 infection is to deploy a digital contact tracing approach that could trace proximal contacts of individuals who are tested positive with COVID-19.

The rapid development of mobile phones and ancillary devices have led to an enormous emergence of mobile health apps and

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related mHealth technology (Estacio et al., 2019; Fox, 2012; Kontos et al., 2014). There are currently more than 320,000 health mobile applications available for the purpose of disease management, healthy lifestyles, disease diagnoses, and medical emergency services (Xie et al., 2018). In 2017, there have been more than 3.7 billion downloads of health apps, with a steady annual growth rate of 16% in the world (Brower et al., 2020). By May 2020, the New Zealand COVID Tracer app was reportedly installed by approximately 380,000 users (Howell & Potgieter, 2020), whereas by Sept. 2020, this app had been installed by 2.1 million New Zealanders (Ministry of Health New Zealand, 2020). This app uses a different approach from the Australian and Singaporean contact tracing apps. The NZ COVID Tracer app acts more like a "digital diary" of users' daily travel and movements. Businesses and restaurants have been provided with a QR code that can be printed and displayed in front of office and store entrances. Users with the NZ COVID Tracer app are encouraged to scan the QR code upon entering a business or restaurant. The visiting details are stored locally in the user's phone and can be deleted after 31 days. There have been concerns regarding inconvenience encountered when using the app, especially with visually-impaired users who would find it difficult to hold up their phones and find the relevant QR code at the entrance of stores and businesses (Howell & Potgieter, 2020). There are also concerns that the app could not log visits at public locations such as beaches, parks, private premises and on public transport (Howell & Potgieter, 2020). These concerns should be addressed by the New Zealand government, given the evidence of infection transmission from public transport in London and New York (Altmann et al., 2020; Howell & Potgieter, 2020; Kenny, 2020).

With more than 3 billion people (30% of the world population) using the internet worldwide (Fernandez-Guerrero, 2020), more people than ever have been relying on the internet and social media to search more information on health, self-care and diseases. A recent report showed that more than 50% of the European population used the internet and social media to look for health-related information (European Commission, 2015), in which more than 20% of people searched for specific information on disease treatment and more than 10% of people used the internet to search for a second opinion after consultation with doctors. Social networks and social media have become a major source of health-related information of people, with Facebook and YouTube being the biggest source of information (Zhang et al., 2017; Zhao & Zhang, 2017). Facebook and YouTube are being used in a large number of countries in all continents from Europe, Asia, Africa and the Pacific islands. With the emerging trend of the use of social media in health information searching, the government and healthcare organisations are increasingly utilizing social media to reach their target population and audience. A report indicated that approximately 95% of US-based hospitals are on social media platforms including Facebook and Twitter (Griffis et al., 2014). It is not uncommon to see most health authorities, including the Ministry of Health New Zealand, have opened their accounts on Facebook, Twitter, Instagram, LinkedIn, and YouTube.

The first generation of contact tracing mobile applications have clearly shown advantages over manual contact tracing approaches, offering key measures to quickly halt the viral spread, facilitating the rapid identification and quarantine of infected individuals. One of the main trade-offs of these contact tracing mobile applications is that people would feel heavily surveilled, with limitations on their personal freedom and their privacy data potentially exposed to app providers or government agencies. Data privacy and social trust have been an issue that may affect the acceptance level of any contact tracing application. Many researchers have referred to the concept of Protection Motivation Theory (PMT) to explain the relationship between social trust and willingness to use a contact tracing app (Borg, 2010; Floyd et al., 2000; Kaspar, 2020; Milne et al., 2000). The Protection Motivation Theory was developed based on the expectancy-value approaches with underpinning health sciences to elucidate any preventive behaviour in the context of threat and coping appraisal cycles (Floyd et al., 2000). In the context of the COVID-19 outbreak, the Protection Motivation Theory refers to the threat appraisal of the potential risk of contracting COVID-19 related diseases and coping appraisal of the suggested preventive behaviour including social distancing and health protective measures. Threat appraisal also refers to any perceived severity and perceived vulnerability related to the failure to conduct preventive behaviour. People's trust in social media was positively impacting users' motivation to provide their personal information and openness (Doherty et al., 2019).

A great number of studies have indicated a strong relationship between user demographics and the adoption rate of mobile health apps (C. Carroll et al., 2002; J. K. Carroll et al., 2017; Ernsting et al., 2017; Krebs & Duncan, 2015). A US-based study showed that nearly 60% of the US population had downloaded at least one health app, and that health mobile app users tended to be more highly educated, younger, had a higher body mass index, and had more income (Krebs & Duncan, 2015). Health mobile app users tended to be more healthy compared to their counterparts who did not use any health apps (J. K. Carroll et al., 2017). A study in Europe also showed an interesting trend where there was a strong connection between age, language spoken, internet use, health status, and intellectual level of users and mobile health application use (Ernsting et al., 2017).

There has been little research on the usage of contact tracing mobile applications during the COVID-19 outbreak in New Zealand. Even a recent large-scale meta-analysis has found little empirical evidence of the effectiveness of automated contact tracing methods (Braithwaite et al., 2020). This meta-analysis conducted by Braithwaite and colleagues in 2020 has intensively searched through key databases including EMBASE, PubMed, and OVID Global Health between 2000 and 2020 regarding the effectiveness, benefits and potential risks when using automated/digital contact tracing methods in infectious disease control. Most review studies involved mobile phone-based contact tracing applications. In addition, wearable devices were also used in some of the studies. It is also unclear about the adoption rate required for a mobile phone-based contact tracing application to be effective. A few studies have also failed to identify any effectiveness of digital contact tracing even under optimal conditions, e.g. more than 75% app adoption rate with high smartphone ownership (Bulchandani et al., 2020; Hinch et al., 2020). Also there has been a very little intensive research on the impact of social trust, risk perception and other demographic factors on the use of the digital contact tracing app.

There are still many uncertainties relating to the epidemiology of this novel COVID-19 virus and to human behaviour under new, untested digital contact tracing methods. With all the above knowledge gaps in the literature, the project and related research methodology mentioned in the next section will contribute to broaden our knowledge about the use of digital contact tracing in the context of the COVID-19 pandemic in New Zealand. Policy makers would be able to improve public acceptability and social trust

around automated/digital contact tracing. In addition, the government agencies would also address any social inequalities that would impact vulnerable populations including older people and homeless individuals who would be less likely to own a modern smartphone.

2. Materials and methods

Encouraged by the small number of quantitative studies noticed in the available academic scholarship and the point that the factors that influence the use of technology for health management is in constant change, this deductive research would use quantitative data to test the proposed hypotheses. This would answer the research question, the relationship analysis between variables-the use of the Contact Tracing app and health management. This research would deal with numbers and would allow for a statistical analysis and graphic data to present the findings.

The questionnaire was designed to collect the information based on the following key determinants: age, gender, ethnicity, employment status, mobile phone use habit, location, motivation to use the NZ COVID Tracer app, user experience of the NZ COVID Tracer app, the user's social trust, their source of news, and the user's attitude towards the COVID-19 pandemic. The items were mostly closed-ended using a five-point Likert scale. At the end of the questionnaire, respondents were requested to give feedback about the NZ COVID Tracer app in an open-ended question. This was an opportunity for the researchers to share any information that had not been asked within the closed-ended questionnaire. The questionnaire was pre-tested with 10 volunteers from ICL Graduate Business School students and staff for measuring the content validity of the questionnaire. Since there was no available complete database of all New Zealanders who use the NZ COVID Tracer app, non-probability sampling was employed to collect the data. A non-probability sampling technique does not require a defined sample frame and is considered the most practical technique in the area of online questionnaires (Saunders et al., 2019). Furthermore, the respondents were reluctant to meet an unknown researcher due to the dangers of possible transmission with COVID19.

Data collection took place via online invitations which were posted on a number of Facebook community forums across New Zealand. To boost the coverage of the study population, requests for retweets were also sent to the New Zealand official COVID-19's Twitter account (https://twitter.com/covid19nz) and the New Zealand Ministry of Health's Twitter account (https://twitter.com/minhealthnz). Facebook's advertising tools were also deployed to boost the recruitment process of study respondents. The data was collected from 261 respondents with a response rate of 75%. Electronic versions of the Participant Information Sheet and Consent Form were clearly displayed and explained in each online questionnaire. Personal information from study respondents such as name and phone numbers were not collected, unless the respondents requested to have a copy of the survey result emailed to them.

The hypotheses have been developed to better understand the profile of the users of the NZ COVID Tracer app including their demography, physical health, and media consumption behaviours. Based on the social trends, the hypotheses were developed to see if there would be a relationship between the use of social media and the usage rate of the NZ COVID Tracer app. In the context of social trust and the Protection Motivation Theory, the hypotheses were developed in this study to test any relationship between social trust and perceived health status and the acceptance of the NZ COVID Tracer app. In this paper, the hypotheses are tested with a significance level of 0.05. The statistical test aims to check whether or not the mean of the sample is significantly different from zero and the probability of the difference originating from a coincidence is 5 out of 100.

The null hypotheses are given below.

H01: There is no relationship between user's age and the usage pattern of the NZ COVID Tracer app.
H02: User's smartphone usage behaviour has no influence on the usage pattern of the NZ COVID Tracer app.
H03: There is no relationship between user's trust in the NZ COVID Tracer app data privacy and the usage of the app.
H04: Having a friend or family member infected with COVID-19 virus has no impact on the use of the NZ COVID Tracer app.
H05: Social media has no influence on the usage rate of the NZ COVID Tracer app.
H06: There is no relationship between users' social trust and the usage rate of the NZ COVID Tracer app.
H07: There is no relationship between a user's perceived health and the use of the NZ COVID Tracer app.
H08: User's attitude toward COVID-19 does not relate to the usage rate of NZ COVID Tracer app.

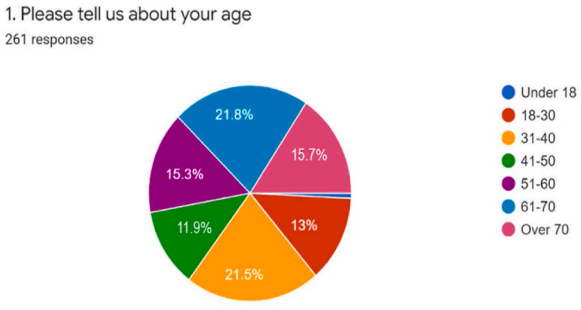

Fig. 1. Age groups of survey respondents.

3. Findings

This section presents and describes the results from the descriptive analysis together with statistical analysis. In total, 261 respondents filled the questionnaire. The descriptive and statistical data analyses are given below:

3.1. Descriptive analysis

To develop an appropriate analysis, the survey had demographic information such as age, gender, ethnicity, employment status and residence within New Zealand. To understand the use of the Contact Tracing app, it was pertinent to ask if the respondents had a smartphone as this health app is only compatible with a smartphone.

3.1.1. Demographics

Fig. 1 describes the age of survey respondents. The age group 61–70 and 31–40 were among the largest groups to complete the questionnaire, accounting for 21.8% and 21.5% respectively. The groups of over 70 and 51–60 years old were 15.7% and 15.3% respectively among total respondents. The group of 18–30 year olds accounted for 13% of respondents. The respondents between 41 and 50 years old made up 11.9% of the total number of respondents. An inconsiderable number of respondents (0.8%) were under 18-years.

Fig. 2 above reflects the gender of the survey respondents. It is worth noting that more than three quarters of the respondents were female. Just more than 20% of respondents were male while the rest (1.1%) preferred not to disclose their gender.

Fig. 3 draws attention to the ethnicity of survey respondents. The majority of the respondents (59.8%) identified themselves as Pakeha/European. The next largest ethnic group of respondents were Asian (33.7%). Maori respondents represented 3.4% of the total respondents while Pacific Islands respondents represented 0.8%. The rest of the respondents identified themselves as other ethnic groups (2.3%).

Fig. 4 above demonstrates the smartphone usage behaviour of respondents. The majority of the respondents used their smartphones most of the time (77.8%). A smaller percentage of respondents (15.3%) revealed that they used their smartphone often. There was 4.2% of respondents who said that they sometimes used their smartphones while a small percentage (2.7%) mentioned that they rarely used their smartphone.

Fig. 5 above shows employment status of the respondents. The largest group of the respondents (31.4%) had full-time employment. It is worth noting that about a quarter of the respondents (25.3%) said they were retired. Respondents in part-time employment made up 18%. Students and homemakers made up 8.4% and 6.5% of total number of respondents respectively. A small percentage (5.4%) of the respondents mentioned that they were unemployed. There was a small number of respondents (5%) who preferred not to reveal their employment status.

Fig. 6 indicates that the majority of the respondents (35.6%) were from Auckland. The Canterbury region accounted for 13% of the respondents; Wellington and Waikato were both 9.6%. The rest of the respondents came from Manawatu/Wanganui, Gisborne, Hawke's Bay, Marlborough, Nelson/Tasman, Northland, Otago, Southland, Taranaki, and the West Coast.

3.1.2. Usage behaviours of NZ COVID tracer app among respondents

Fig. 7 above shows the NZ COVID Tracer App installation behaviour of respondents. More than 90% of respondents mentioned that they have installed the NZ COVID Tracer app at some point. There were 19 out of 261 respondents who had never installed the NZ COVID Tracer app.

Fig. 8 describes the usage behaviour of the NZ COVID Tracer app among the respondents. Most respondents mentioned that they used the NZ COVID Tracer app all the time (38.7%) or most of the time (32.6%). Less than one-fifth of respondents described that they sometimes used the app (17.6%). Less than 10% of respondents have never used the NZ COVID Tracer app. There were 6 out of the 261 respondents who mentioned that they rarely used the contact tracing app, accounting for 2.3% of total respondents.

When being asked about the reasons for using the NZ COVID Tracer app (Fig. 9), most of the respondents mentioned that they wanted to show responsibility to the community (79.3%), to protect their family and friends (68.6%), and to help stop the infection outbreak (75.9%). Approximately half of the respondents (51%) wanted to use the contact tracing app in order to know the risk of infection. Less than half of the respondents mentioned that they used the contact tracing app to reduce mortality in older people

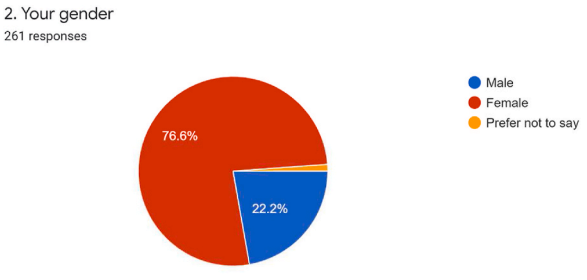

Fig. 2. Gender of the respondents.

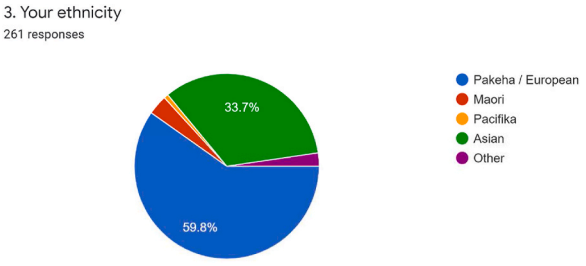

Fig. 3. Ethnic groups of respondents.

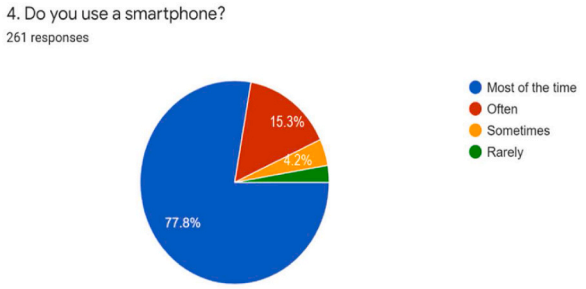

Fig. 4. Smartphone usage among respondents.

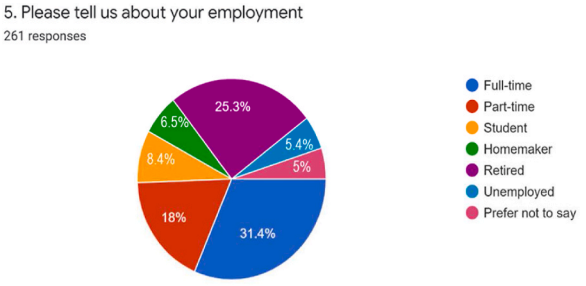

Fig. 5. Employment status of the respondents.

(34.1%), for peace of mind (44.8%), or to help them stay healthy (42.5%).

When being asked about features that made the NZ COVID Tracer app a good mobile application (Fig. 10), the majority of the respondents (87%) agreed that the app was simple and easy to use. However, less than half of the total number of respondents mentioned that the app had a user-friendly interface and graphic design. Similarly, less than half of the total respondents agreed that the NZ COVID Tracer app was speedy or operated efficiently. Only 23.8% of total respondents showed their concern that the NZ COVID Tracer app had a few bugs and technical errors.

When being asked about app features that were missing from the NZ COVID Tracer app (Fig. 11 above), more than a third of respondents mentioned that the app could not record the check-out time of each location visit. Nearly 20% of respondents mentioned that the contact tracing app did not have a Bluetooth feature nor did it have a GPS mapping function. Other concerns mentioned included time consumption (17.2%), slow loading (7.3%), bugs and technical errors (7.3%), battery consumption (3.8%) and other reasons. It is worth noting that approximately a third of total respondents were happy about the app and agreed that the app worked well.

3.1.3. User's trust in data privacy

When being asked about the trust in data privacy from the NZ COVID Tracer app provider, the majority of respondents either strongly agreed (28.4%) or agreed (38.3%) that the app provider would protect their personal data and related privacy. Approximately a third of total respondents held a neutral opinion about the issue. There were a small percentage of respondents who disagreed (1.1%) and strongly disagreed (3.4%) that the app provider would protect their personal data privacy (Fig. 12). This is also an indication that those who trust the data protection were using the Contact Tracing app as the majority of the survey respondents were using this app.

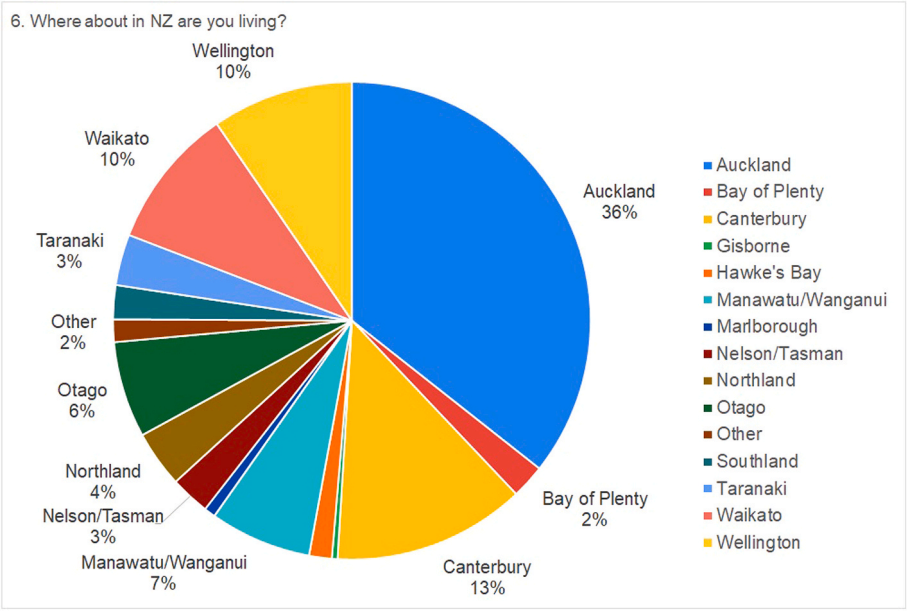

Fig. 6. Residing areas of survey respondents.

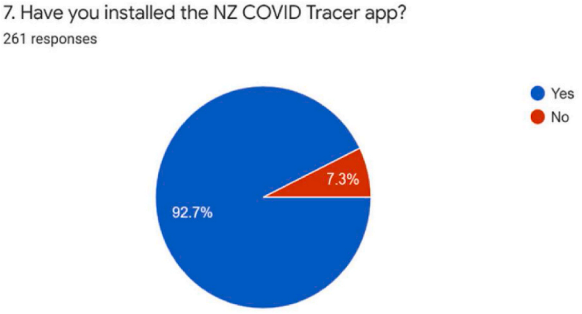

Fig. 7. NZ COVID Tracer app installation status by respondents.

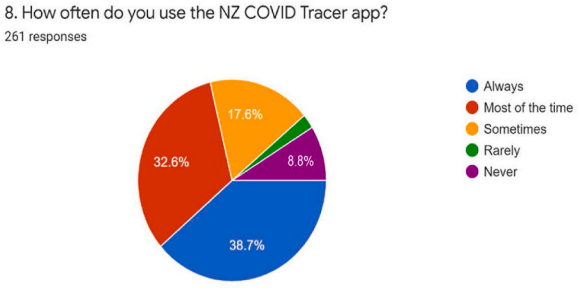

Fig. 8. NZ COVID Tracer app usage behaviour.

3.1.4. Mandatory use of the NZ COVID tracer app

A large proportion of respondents (65.9%) showed support for the idea about a mandatory use of the NZ COVID Tracer app (Fig. 13). There was 13.8% of total respondents who disagreed that the New Zealand government should apply a mandatory use of the contact tracing app. However, approximately one-fifth of the total respondents did not make a decision around the issue.

3.1.5. User's trust about social distancing practice in New Zealand

The respondents were asked for their opinion on the social distancing practice in New Zealand (Fig. 14). More than 33% of total

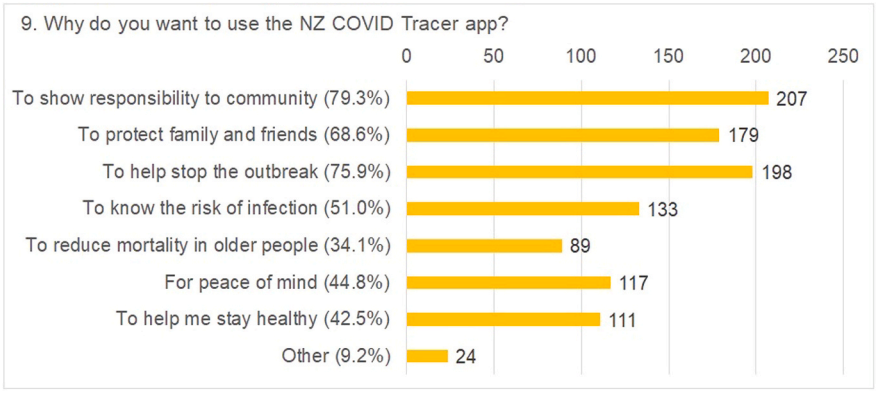

Fig. 9. Reasons to use NZ COVID Tracer app.

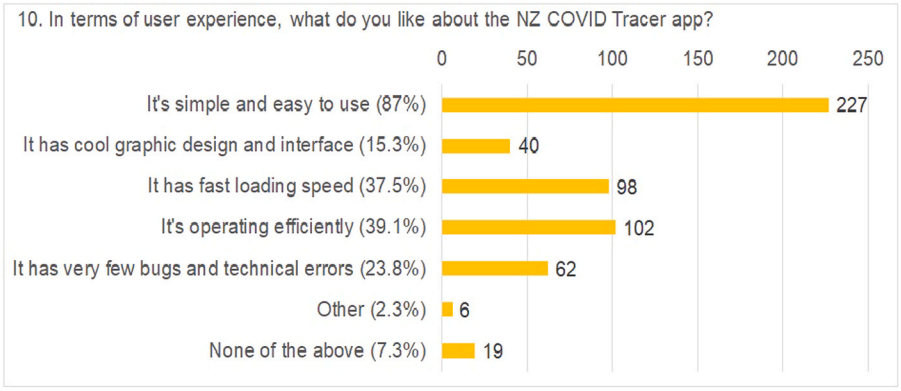

Fig. 10. Contact tracing app features.

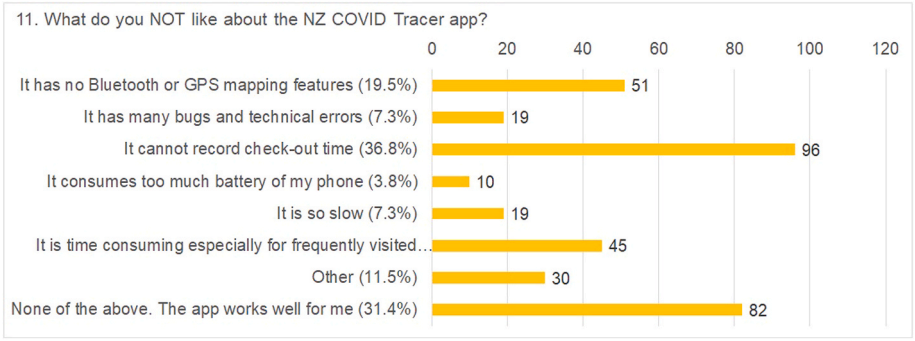

Fig. 11. App features that need improvements.

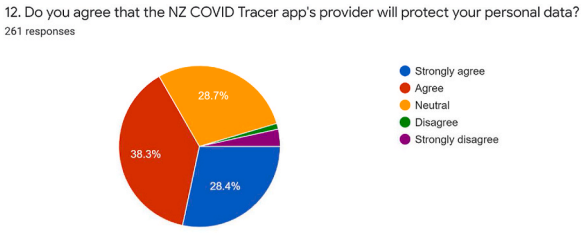

Fig. 12. User's trust in data privacy protection.

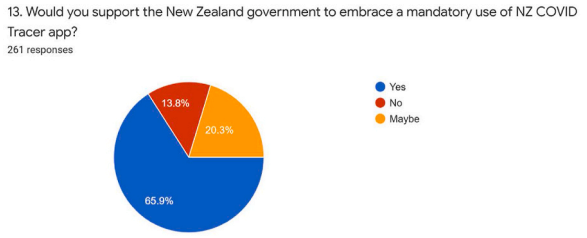

Fig. 13. User's support for mandatory use of NZ COVID Tracer apps.

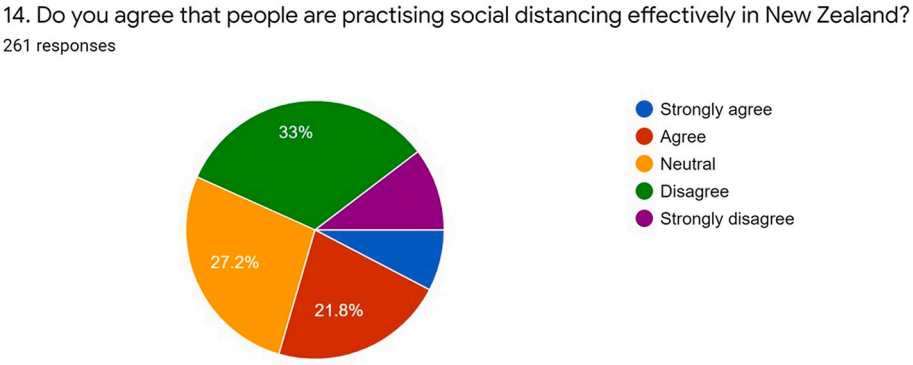

Fig. 14. User's trust about social distancing practice.

respondents disagreed that people were practicing social distancing effectively in the country. Approximately 10% of respondents showed strong disagreement about the statement. Nearly 30% surveyed remained neutral. The proportion of people who strongly agreed and agreed were 7.7% and 21.8%, respectively which means a very small percentage agreed that people were maintaining social distancing.

3.1.6. Sources of news and motivation to use the NZ COVID tracer app

Fig. 15 above shows the main sources of news for COVID-19 being used by the respondents. In Fig. 15, respondents mentioned that their major sources of information on COVID-19 included Facebook (62.5%), news websites (57.9%) and television (56.3%). Other sources of information were government websites (37.5%), newspapers (23%), email alerts and newsletters (17.2%), Twitter (2.7%), and other sources (4.6%) (see Fig. 16).

Interestingly, when being asked about the media sources that made them use the contact tracing app more often, among the listed sources of motivation, television (46.4%) and Facebook (40.6%) motivated respondents to use the NZ COVID Tracer app. The other sources remained less significant, including newspapers (18.8%), news websites (28.4%), government websites (29.5%), email alerts and newsletters (22.2%), Twitter (1.1%), and other sources (16.1%). Less than 1% of the total respondents mentioned that none of the listed were sources of motivation for them.

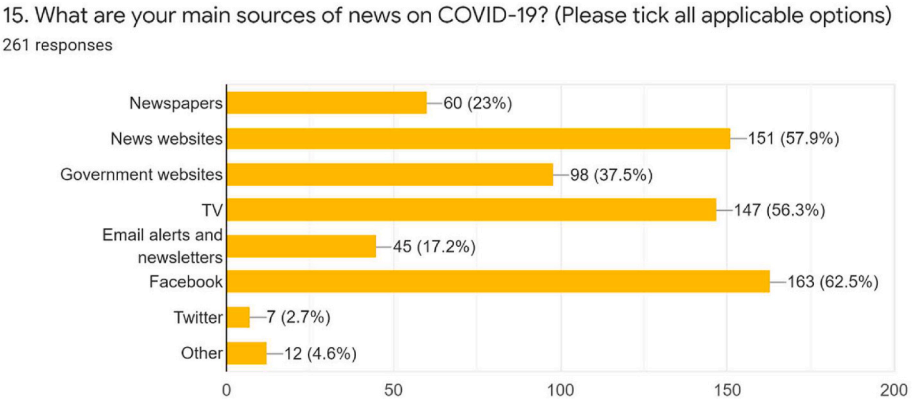

Fig. 15. Main sources of news for COVID-19.

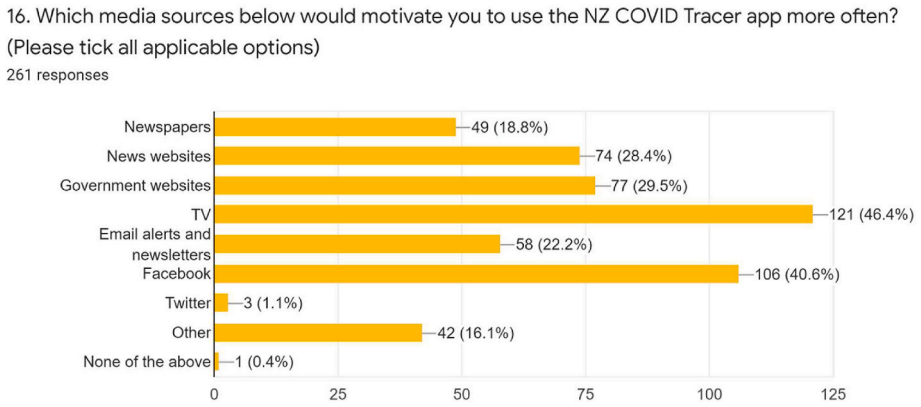

Fig. 16. Media sources to motivate the use of NZ COVID Tracer app.

3.1.7. User's perceived health status and attitudes towards COVID-19

Fig. 17 describes respondents' self-perceived health status. A large proportion of total respondents (42.5%) self-described their health as being very good. There were 24.5% of the total respondents describing their current health as excellent. A similar percentage of respondents (24.9%) claimed having good health. There were small proportions of the respondents describing their health as fair (6.9%) and poor (1.1%). It is worth noting that the majority of respondents (74.3%) mentioned that they did not have any long-term health conditions which included diabetes, asthma, or heart problems, as shown in Fig. 18 above.

Fig. 19 above describes the respondents' attitudes towards the COVID-19 pandemic. The percentage of respondents who were very afraid of the COVID-19 virus were 11.1% and 20.3% respectively. Approximately 20% of respondents showed a neutral attitude toward the pandemic, whereas nearly 40% of the total respondents mentioned that they were a little afraid of the COVID-19 virus. Some respondents mentioned that they were not afraid of the coronavirus at all, accounting for 11.1% of total respondents (see Fig. 20).

When being asked whether any family or friends had become infected with the COVID-19 virus, the majority of respondents did not have any. There were 12.6% of the total respondents who said that they knew of someone having the disease. An insignificant number of respondents (0.8%) did not want to reveal this information.

3.2. Statistical analysis results

This section presents the results of hypotheses using statistical analyses. A combination of influential factors on contact tracing mobile application usage behaviour is assessed as a whole regression model. Each individual influential factor is also examined as a single relational model for the NZ COVID Tracer app usage behaviour. A multiple linear regression analysis was performed to predict the frequency of use of the NZ COVID Tracer App based on age, smartphone usage behaviour, the user's perceived health and attitude towards COVID-19, having a friend or family member infected with COVID-19, issues of trust around privacy in the app provider, and user's trust of others' social distancing behaviour. The model has an R2 value of 0.322. Age, smartphone usage behaviour and the user's trust on privacy protection from the app provider have shown an impact on NZ COVID Tracer App usage. There is a description below from an R computational statistical package which describes the linear model predicting usage behaviour of the NZ COVID Tracer App. For other factors that did not have a statistically significant impact on app usage behaviour, a linear regression analysis was also performed to confirm if there was no actual statistical relationship.

The statistical analysis in Table 1 shows that there is a relationship between the usage of the NZ COVID Tracer app by age, smartphone usage and trust in the privacy of the data and protection. Hence the null hypothesis 1 (0.002), hypothesis 2 ($p < 0.001$) and hypothesis 3 ($p < 0.001$) are rejected. However, there is no relationship between the usage of the NZ COVID Tracer app with self-perceived health, fear of COVID-19, knowing some family member or friend affected with COVID-19 and social distancing practices. Hence null hypotheses 4–8 are accepted. This could be areas of further research to explore. However, the present study discusses only the variables that have a statistical relationship (see Table 2).

4. Discussion

This section discusses the relationships between usage behaviour of the NZ COVID Tracer app and key influential factors including age groups, smartphone usage behaviour, social media use, user's attitudes towards the COVID-19 pandemic, and user's trust of data privacy protection.

4.1. Age and adoption rate of NZ COVID Tracer App

Previous studies have indicated that older people often had difficulties accessing and using mobile technologies and applications including mHealth technologies (Drew et al., 2020; Grantz et al., 2020; Rai et al., 2013). However, the present study showed that

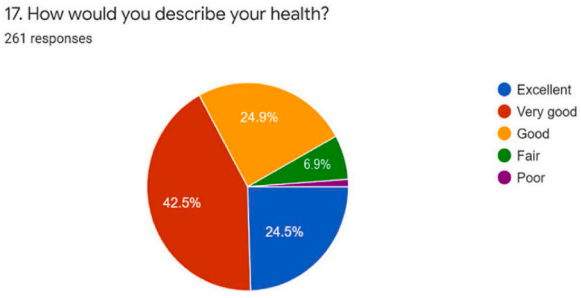

Fig. 17. User's perceived health status.

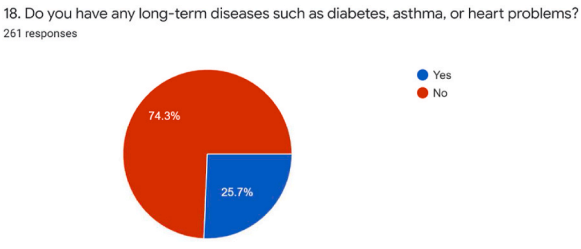

Fig. 18. User's current health issues.

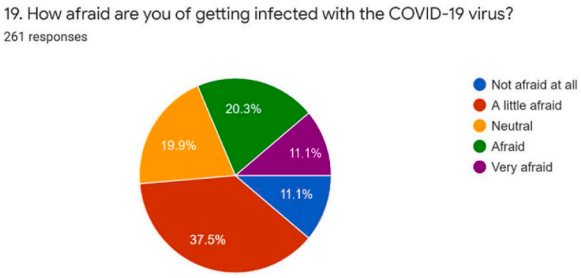

Fig. 19. User's attitudes towards COVID-19.

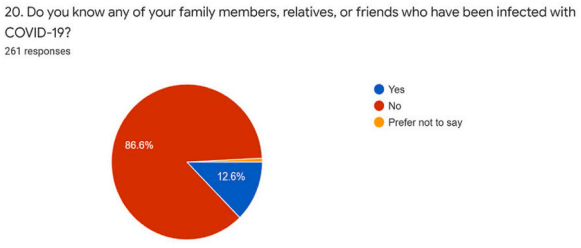

Fig. 20. User's acquaintances of someone infected with COVID-19.

people older than 70 in New Zealand had used the NZ COVID Tracer app. Approximately 40% of study respondents over 70 years old indicated that they had always used the contact tracing app. However, there was approximately 10% of people in this group who indicated that they never used the NZ COVID Tracer app. Perhaps some of the older people had found difficulties accessing smartphones and related mobile technologies. On the other hand, respondents, including the groups 18–30 and 31–40, seemed to have used the contact tracing app at a moderate frequency, with the majority of them using the apps only sometimes during the day.

In this study, approximately 60% of survey respondents were of European descents whilst approximately 30% of respondents were from Asian heritages. Only about 3% of respondents were Māori and less than 1% of respondents were from Pacific ethnic groups. It is worth noting that Māori and Pacific is the second and third largest ethnic group (16.5% and 8.1%, respectively) after European ethnicity in New Zealand, according to recent Census study (Stats, 2020). The finding indicates that participants from Māori and

Table 1
Multiple linear regression description of factors on NZ COVID Tracer app usage behaviour.

	Usage behaviour of NZ COVID Tracer app		
Predictors	Estimates	CI	p
(Intercept)	−0.16	−1.29–0.96	0.774
Age	0.13	0.05–0.21	0.002
Smartphone usage	0.55	0.36–0.74	<0.001
Self-perceived health	−0.03	−0.17–0.11	0.669
Fear of COVID-19	−0.06	−0.17–0.04	0.239
Knowing someone infected with COVID-19	−0.04	−0.38–0.31	0.835
Trust in data privacy protection	0.50	0.36–0.63	<0.001
Trust in social distancing practice	−0.05	−0.17–0.06	0.351
Observations	261		
R2/R2 adjusted	0.322/0.303		

Table 2
Breakdown information on devices used by survey respondents.

Device platform	Reach	Impressions	Frequency	Results
Mobile app	3,438	3,992	1.16	132 Link Clicks
Desktop	1,432	1,706	1.19	53 Link Clicks
Mobile web	264	298	1.13	5 Link Clicks
Total results 3/3 rows displayed				

Pacific ethnic background less likely to pay attention to health and wellbeing. Another reason could be that Māori and Pacific people have less access to a smartphone or computer, hence only few of them were able to take part in this survey. More investigation would be needed to understand how people from multiple ethnic background would be affected by the COVID-19 pandemic. Although there was a linear statistical relationship between app usage and residing areas of respondents (P-value < 0.05), future studies can be performed with larger sample sizes to better understand the impact from geographic location of respondents on contact tracing app usage. Further investigation would also be needed in order to determine key factors affecting the behavioral intention of using the contact tracing app within these groups. Perhaps the people in these groups had busy lifestyles that made using a contact tracing app more inconvenient.

The health belief model (HBM) and protection motivation theory (PMT) were used to explain how age would affect the adoption rate of mHealth mobile technologies, including the usage of a contact tracing app. Initially developed by Becker in 1974, the health belief model determines a decision on health-related action based on one's self-evaluation of perceived disadvantages of not taking the action and the perceived advantages of taking the action (Becker, 1974). Similarly, the protection motivation theory developed by Rogers in 1975 predicts a health-related action by assessing the threat appraisal (e.g., self-perceived severity) and coping appraisal (e.g., self-perceived usefulness) processes (Rogers, 1975). Obviously, as age increases, people's physical and psychological conditions change gradually. Several studies have found that age plays a significant role in threat appraisal and coping appraisal processes in health-related decision making processes (Guo et al., 2015; Reuter et al., 2010). Age, trust and behavioral intention to use mobile health apps were different between the older group, the middle-aged and younger people (Guo et al., 2015). The elderly also tended to have greater self-perceived vulnerability and self-perceived severity than younger people (Guo et al., 2015). Older people are more likely to suffer from illness and long-term diseases such as high blood pressure and diabetes; therefore, they would pay more attention to their health-related issues, and are more likely to take actions to avoid illnesses. As a result, older users of mobile health technologies tend to have a higher adoption rate compared to younger people.

4.2. Smart phone usage and related impact on contact tracing app usage

The study has shown a statistically significant relationship between smartphone usage and adoption rate of the NZ COVID Tracer app. People with frequent smartphone usage tended to use the NZ COVID contact tracing app more regularly. In the era of COVID-19 pandemic, mobile phones and related smartphone applications have proved to possess unique opportunity to help coordinate and perform healthcare related interventions and support with government responses. Not only do people use smartphone for contact tracing purpose, they also use smartphone to access COVID-19 related information and other health information. Referring to Facebook Ads campaign related to this study, it can be seen that the majority of the respondents accessed to this survey through their smartphones rather than from a desktop or computer (2). Mobile smartphones have really shown their ability to help governments improve the public health and clinical systems, reducing the burden caused by COVID-19 outbreak.

Obviously, a high adoption rate of a contact tracing app would require a ubiquitous use of smartphones within the population. This

issue might also create an ethical dilemma where people would be forced to carry their smartphones all the time with them. While smartphone addiction has been recognized as an issue with teenagers and younger adults (Gentina & Rowe, 2020), this ethical dilemma seems to make the smartphone addiction worse in the population. In addition, teenagers and younger adults tended to less concern about their data privacy issues (Rowe, 2020), making the idea that their privacy and personal data belong to the government more legitimized.

4.3. Data privacy protection and related impact on contact tracing app usage

In this study, the respondents with greater concern about data privacy seemed to use the NZ COVID Tracer app less frequently. This finding aligns with other empirical studies. In fact, data privacy has been seen as one of the biggest concerns from users of mobile health applications, especially for contact tracing purposes. A recent study conducted in the Netherlands has indicated that more than half of the respondents mentioned privacy concerns as the main reason for not using a contact tracing app (Jansen-Kosterink, Hurmuz, Ouden, & Velsen, 2021). The privacy dilemma has been a huge issue for governments all over the world, especially in Western countries where people's privacy and freedom are regarded as a fundamental human right. In fact, the privacy issue was one of the biggest hurdles that made the United Kingdom's contact tracing app fail to be adopted by people the first time, mainly because they did not have sufficient trust in the app and related privacy protection (Cellan-Jones, 2020). The discussion about how data privacy could be protected using different technology architecture, such as decentralized or centralized systems, has been going on in many government meetings across the United Kingdom, Belgium, France, Germany and the United States (Rowe, 2020). The French government also rejected a technological offer from Google and Apple regarding privacy protection, and intended to develop its own nation's technology system to protect user's data privacy (Rowe, 2020). Many governments wanted to develop their own national information technology security system, as a symbol of national sovereignty, to obtain trust from the citizens (Rowe, 2020). In the case of the NZ COVID Tracer app, the New Zealand government has opted to not incorporate Bluetooth technology into the mobile application in the beginning, since this technology has been notoriously known to be data breach prone (Culnan & Williams, 2009). Technology giants also play an important part in order to assure users about the data privacy concerns. France and United Kingdom have opted for a centralized system while Germany chose to develop its contact tracing app based on a decentralized approach. While many countries, including Singapore and Australia, chose to use Google and Apple's technology in their contact tracing applications, France and the United Kingdom preferred to develop their own national technologies. In Singapore, the government has partnered with WhatsApp to send accurate information about COVID-19 and government initiatives to the public (Ting et al., 2020). Alongside data privacy protection concerns, the concept of freedom is the key issue that may impact on the adoption rate of a contact tracing app. If the contact tracing app was to be made mandatory for all citizens, some people may be excluded. Similarly, if social pressure toward the use of a contact tracing app, some people might feel uncomfortable using the contact tracing app with a trade-off for their freedom. In addition, people might not fully understand the technology deployed by the government and would falsely think that these technologies would not adequately protect their data privacy.

5. Conclusion

To sum up, age, smartphone usage behaviour, and user's trust on data privacy protection would have a significant impact on usage behaviour of a contact tracing mobile application. User's trust in data privacy protection has shown to be a key factor impacting usage behaviour of a contact tracing mobile application. Different measures should be deployed to improve user's trust on personal data protection, which in turn would encourage more people to use the NZ COVID Tracer app in a proper way. These measures could include an education and information campaign on how app providers and government agencies would ensure privacy protection for end-users. Information on the technical system of the contact tracing app could have been published regarding how technologies were designed to protect users' privacy, which in turn would reassure people regarding their concern with data privacy. However, alternatives to the mobile contact tracing app should be introduced, which may address the concern of data privacy and freedom restriction from users. Finally, various social and psychological approaches could be examined to encourage people to use the contact tracing mobile app with less fear of privacy invasion. For example, an additional design of the contact tracing app, in which a display of how many other people have nearly installed the contact tracing app, could encourage more people to install the app for the sake of public health.

Several respondents mentioned in an open-ended question of the survey that they could not use the NZ COVID Tracer app due to the incompatibility of their phone, either having a legacy operating system or dated hardware. A few respondents in their 80's mentioned that they were too old to use a smartphone and hoped they would be out of reach of the deadly virus. Other respondents mentioned the inconvenience that they had to check in their frequently visited businesses, including their workplaces, schools and kindergartens. In general, apart from people having old smartphones that could not run the NZ COVID Tracer app smoothly, respondents were happy about the contact tracing app and wished to continue with what they have been doing in order to stop the outbreak and protect their family and community. As the New Zealand public started using the digital technology for tackling the COVID-19 pandemic, the government also encouraged people to use it. This successful application of digital technology will probably increase the public and governmental acceptance of such technology for addressing other areas of healthcare including chronic disease in the future.

6. Limitations and future directions

This study was conducted with a relatively small sample size of 261 respondents, therefore, it would not be perfectly representative

of the New Zealand population. Further studies could be carried out with a significantly larger sample size. A recent study sponsored by a New Zealand governmental agency on the willingness of New Zealanders to download a contact tracing app just before the release of the NZ COVID Tracer app in May 2020, was conducted with a contribution of more than 1000 respondents (Hercock & Dudding, 2020). It is suggested that a sample size of more or less than 1000 respondents should be more representative of people throughout Aotearoa.

The data was collected through online platforms so it has an inherent bias of collecting information from online media users.

In addition, this project focused more on the relationship between various factors and the usage behaviour of the NZ COVID Tracer app, without an in-depth examination of users' experience on the contact tracing app. Further investigation on users' experience of the NZ COVID Tracer app could be conducted in the future, which would analyze the design and technological improvements for newer versions of the app. Further research could be carried out to understand how people would be willing to trade off their privacy for their community's common health interest. Obviously, we should continue to invest in computational technologies and the applications of cryptographic procedures, so that smartphone-based applications could be widely adopted with minimal invasion of privacy. Since the peoples' invitation to the project was carried out completely based on a Facebook platform, further research could be conducted outside this platform, such as emails or a face-to-face recruitment method. Finally, a qualitative or mixed methods research could also be conducted to capture user's perspectives that could not be collected using quantitative approaches.

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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