

Predictors to use mobile apps for monitoring COVID-19 symptoms and contact tracing: A survey among Dutch citizens.

Stephanie Maria Jansen-Kosterink, Marian Hurmuz, Marjolein den Ouden, Lex van Velsen

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Abstract

Background: eHealth applications have been recognized as a valuable tool to reduce COVID-19's effective reproduction number. The factors that determine acceptance of COVID-19 apps are unknown. The exception here is privacy.

Objective: The aim of this article was to identify antecedents of acceptance of 1) a mobile application for COVID-19 symptom recognition and monitoring, and 2) a mobile application for contact tracing, both by means of an online survey among Dutch citizens.

Methods: Next to the demographics, the online survey contained questions focusing on perceived health, fear of COVID-19 and intention to use. We used snowball sampling via posts on social media and personal connections. To identify antecedents of the model for acceptance of the two mobile applications we conducted multiple linear regression analyses.

Results: In total, 238 Dutch adults completed the survey. Almost 60% of the responders were female and the average age was 45.6 years (SD±17.4). For the symptom app, the final model included the predictors age, attitude towards technology and fear of COVID-19. The model had an r^2 of 0.141. The final model for the tracing app included the same predictors and had an r^2 of 0.156. The main reason to use both mobile applications was to control the spread of the COVID-19 virus. Concerns about privacy was mentioned as the main reason not to use the mobile applications.

Conclusions: Age, attitude towards technology and fear of COVID-19 are important predictors of the acceptance of COVID-19 mobile applications for symptom recognition and monitoring and for contact tracing. These predictors should be taken into account during the development and implementation of these mobile applications to secure acceptance.

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Original Manuscript

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Keywords: COVID-19; eHealth; mHealth; contact tracing; symptom management; intention to use.

Introduction

It is spring 2020 and the COVID-19 pandemic has the world in its grip. Infection with COVID-19 can lead to a simple cold or no symptoms at all, while it can also rapidly develop into a life threatening disease, especially for patients with existing cardiovascular problems, obesity, or diabetes [1]. In order to hamper the spread of COVID-19 and to manage the intensive care unit capacity, many countries have applied a lockdown strategy for their citizens [2]. In order to control the spread of COVID-19 after a lockdown, and to minimize the effective reproduction number of the disease, several measures can be applied, of which social distancing, combined with aggressive case-finding and isolation seem to be the most effective [3].

eHealth applications have been recognized as a valuable tool for supporting symptom recognition and monitoring [4], for contact tracing [5], and ultimately, for reducing COVID-19's effective reproduction number by means of timely intervention. In short, a contact tracing app would record a citizen's contacts with other people via Bluetooth technology and, in the case of a COVID-19 infection, will warn the persons that the index patient recently had contact with so that they can apply self-isolation and be attentive for any COVID-19 symptoms. However, for such applications to be effective, high uptake among the population is necessary. For the case of a tracing application, it has been estimated that 56% of a country's population should use the application to suppress the epidemic [6]. It is therefore crucial that the design of these applications and the implementation strategies that accompany them take the factors that affect acceptance into account.

The factors that determine acceptance of COVID-19 apps are largely unknown [7]. The exception here is privacy. Since the first plans of governments to implement these technologies, a fierce public debate has erupted on whether or not large scaling tracing of contacts for this goal is an unacceptable breach of privacy or not. While the issue of privacy has been recognized as an important antecedent of acceptance of mobile health applications [8], the unique and disturbing situation that the COVID-19 pandemic places us in, makes it difficult to apply existing models and frameworks for eHealth acceptance. In May 2020 the Dutch government wanted to develop and implement two mobile applications to prevent the spread of the COVID-19 virus and support Dutch municipal health services. The aim of this article was to identify antecedents of acceptance of 1) a mobile application for COVID-19 symptom recognition and monitoring, and 2) a mobile application for contact tracing, both by means of an online survey among Dutch citizens.

Methods

To identify antecedents of acceptance of a mobile application for COVID-19 symptoms recognition and monitoring (hereafter: symptom app), and a mobile application for contact tracing (hereafter: tracing app), an online survey was developed, tested and distributed among Dutch citizens. This study did not require formal ethical approval (as ruled by CMO Oost Nederland, file number: 2020-6628). At the beginning of the survey, participants were asked for consent to use their data for research purposes.

Survey

The online survey (see Multimedia Appendix 1) consisted of four parts. The first part included questions on demographics, the second part contained questions related to perceived health, the third part consisted of questions related to the fear of a COVID-19 infection, and the final part included questions to assess the intention to use the two suggested mobile applications. In April 2020, the Dutch government announced plans to develop and implement two mobile applications for preventing the spread of the COVID-19 virus. However, the exact design of these applications remained unknown at this time. Therefore, we introduced both mobile applications in the survey via a short description of their general aim. We pre-tested the survey with 14 Dutch citizens to improve legibility.

Demographics

We assessed gender, age, smartphone use, educational level (student, primary school, secondary school, high school, bachelor's degree / University / PhD), work status (unemployed and searching for work, not able to work due to illness, volunteer work, part-time work, full-time work, retired, student), income level (below average wages, average wages, above average wages) and living status (living alone, living together, other). We assessed the participants' attitude towards technology, using the Personal Innovativeness in the Domain of Information Technology scale by Agarwal & Prasad, 1998 [9], consisting of four statements and accompanied by a five-point Likert scale (ranging from 1 (strongly disagree) to 5 (strongly agree)). Finally, we also asked whether participants were (once) infected with COVID-19. The answer options for this question were: Yes, In doubt, or No.

Perceived health

To assess perceived health, we asked participants to complete three questions. These questions were used previously to assess perceived health among Dutch citizens [10]. These questions/statements were: 1. How would you describe your health?; 2. How concerned are you about your health?; and 3.

I am ill more often than other people of the same age and sex. These were accompanied by a five-point Likert scale ranging from 1 (bad, not concerned and totally disagree, respectively) to 5 (excellent, very concerned and totally agree, respectively).

Fear of COVID-19

The participants' fear of a COVID-19 infection was assessed by means of four questions related to this topic:

- Have you been concerned about the outbreak of the COVID-19 virus in recent weeks?
[five-point Likert scale, ranging from 1 (not at all concerned) to 5 (extremely concerned)];
- How often did you think of the outbreak of the COVID-19 virus in recent weeks?
[five-point Likert scale, ranging from 1 (never) to 5 (always)];
- How afraid were you of the outbreak of the COVID-19 virus in recent weeks?
[five-point Likert scale, ranging from 1 (not afraid at all) to 5 (very afraid)];
- How afraid are you of getting sick from the COVID-19 virus?
[five-point Likert scale, ranging from 1 (not afraid at all) to 5 (very afraid)].

Intention to use

Finally, participants were asked to rate their intention to use the two mobile applications: 1) a symptom app, and 2) a tracing app. The statements for the construct intention to use were based on Van Velsen et al., 2015 [11]. All three questions were accompanied by a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Next to these closed questions, respondents were also asked what the main reasons were to 'use' and 'not to use' the mobile applications.

Survey distribution

Distribution of the survey (via QualtricsXM) started on April 15, 2020. Participants were eligible if they were 18 years of age or older. We used a snowball sampling via posts on social media (LinkedIn, Twitter and Facebook) and personal connections. Next to this, we recruited participants via a Dutch panel of older adults that indicated they were interested in participating in research on the topic of eHealth. The survey was closed on April 30, 2020. Due to the method of recruitment, a response rate could not be calculated.

Analyses

Data were analysed by using Statistical Package for the Social Sciences, version 19. Descriptive statistics were performed for all outcomes. Cronbach's alphas were calculated to assess internal consistency for attitude towards technology, perceived health, fear of COVID-19 and intention to use. Next, survey scores were interpreted for these factors as being negative (score 1 or 2), neutral (score of 3), or positive (score 4 or 5). Via a paired t-test, the difference in intention to use score between both mobile applications was tested. To identify antecedents of acceptance of 1) a symptom app, and 2) a tracing app, we conducted multiple linear regression analyses (backward model analyses). The intention to use each app was used as the dependent variable. The independent variables were selected based on Pearson Correlation coefficients. Demographic characteristics and factors that (borderline) significant correlated (Pearson Correlation cut-off level $p \leq 0.10$) with the dependent variable "intention to use" were included in the multiple linear regression analyses. For the paired t-test and regression analyses, the level of significance was set at $P < 0.05$. For the final models the r^2 was calculated. The r^2 indicates the percentage of the variance in the dependent variable that the independent variables explain collectively. To support the quantitative results, the responses on the two open questions were sorted and counted by the first author and discussed with

the second author, taking an inductive approach. Disagreements were discussed until unanimous agreement was reached.

Results

In total, 238 Dutch citizens completed the survey. Fifteen responders only completed the intention to use survey of a tracing app as this app was presented first and these responders stopped with the survey after these questions. Almost 60% of the responders was female and the average age was 45.6 years ($SD \pm 17.4$). Only five responders (2.1%) did not own a smartphone and almost 75% claimed that they carried their smartphone with them for most of the day. The average age of our sample is higher than the average age of the Dutch population. Next to this, there is in our sample an overrepresentation of female participants and participants with a high education level [12]. Compared to statistics of 2018 there is an overrepresentation in our sample of participants owning a smartphone and compared to statistics of 2020 there is an underrepresentation in our sample of participants who are unemployed [12]. The internal consistence of the attitude towards technology scale was good (Cronbach's Alpha = 0.85). Most responders (73.9%) had a moderate attitude towards technology. Only three responders (1.3%) claimed to be infected with COVID-19. All demographic characteristics are presented in Table 1.

Table 1. Responders' demographics.

Demographic (n=238)		
Gender		
	Male	40.8%
	Female	59.2%
Age		M=45.6 ($SD \pm 17.4$) years
Smartphone		
	Yes	97.9%
	No	2.1%
Carry smartphone with you?		
	Always	74.8%
	Sometimes	23.1%
	Never	2.1%
Education level		
	Student	6.7%
	Primary school	0.8%
	Secondary school	5.9%
	High school	23.9%
	Bachelor's degree / University / PhD	62.6%
Work status		
	Unemployed and searching for work	1.3%
	Not able to work due to illness	3.4%
	Volunteer work	0.8%
	Part-time work	31.5%
	Full-time work	34.4%

	Retired	18.1%
	Student	10.5%
Income level		
	Below average wages	31.9%
	Average wages	39.1%
	Above average wages	29%
Living status		
	Living alone	14.3%
	Living together	80.3%
	Other	5.5%
Attitude towards technology		M=3.2 (SD±0.78) [1-5]
	Low (1-2)	1.3%
	Moderate (3)	73.9%
	High (4-5)	24.8%
COVID-19 infection		
	Yes	1.3%
	In doubt	18.5%
	No	80.3%

Fear of a COVID-19 infection

The internal consistency of the four items in this scale was acceptable to good (Cronbach's Alpha = 0.78). The mean score on this topic was 3.3 (SD±0.68). The majority of the responder's opinion on this topic was neutral (80.7%) and 16% of the responders were afraid for a COVID-19 infection. Only a few responders (3.4%) were not afraid (Table 2).

Perceived health

For the three items to assess the perceived health of the responders the internal consistence was acceptable (Cronbach's Alpha = 0.69). The mean score on this scale was 3.8 (SD±0.68). Most respondents were positive about their health (58.4%).

Intention to use

The intention to use was assessed for the symptom app and the tracing app. For both scales, internal consistency was excellent; Cronbach's Alpha symptom app = 0.96 and Cronbach's Alpha tracing app = 0.96. For both apps, the majority's intention to use was neutral (see Table 2). However, an additional paired t-test indicated that there is a significant difference in the scores on intention to use for the symptom app (M=3.38, SD±1.07, N=223) and the tracing app (M=3.27, SD±1.13, N=223); $t(222)=-2.598$ and $P=.01$. Indicating that the responders were more willing to use a mobile application for COVID-19 symptom recognition and monitoring compared to a mobile application for contact tracing.

Table 2. Descriptive statistics and internal consistency of scales.

Scale	Number of items	Cronbach's Alpha	Mean (SD)	Positive	Neutral	Negative
Fear of COVID-19	4	0.78	3.3 (SD±0.68)	16%	80.7%	3.4%
Perceived health	3	0.69	3.8 (SD±0.68)	58.4%	40.8%	0.8%
Symptom app (n=223)						
Intention to use	3	0.96	3.38 (SD±1.07)	45.3%	45.3%	9.4%
Tracing app (n=238)						
Intention to use	3	0.96	3.27 (SD±1.14)	41.2%	45.4%	13.4%

Correlations

The intention to use a symptom app is related to income level ($r=0.132$, $P=.05$), attitude towards technology ($r=0.220$, $P<.001$) and fear of COVID-19 ($r=-0.291$, $P<.001$). The intention to use a tracing app is related to age ($r=0.135$, $P=.04$), attitude towards technology ($r=0.223$, $P<.001$) and fear of COVID-19 ($r=-0.303$, $P<.001$). Based on these outcomes the independent variables within the linear regression analysis were: age, income level, attitude towards technology, fear of COVID-19 and perceived health. Table 3 provides an overview of the correlations between all demographics and factors, and the intention to use.

Table 3. Outcome Pearson Correlation.

	Intention to use symptom app (n=223)	Intention to use tracing app (n=238)
Gender	$r=-0.056$ $P=.41$	$r=-0.147$ $P=.23$
Age	$r=0.126$ $P=.06$	$r=0.135^*$ $P=.03$
Education level	$r=0.21$ $P=.76$	$r=0.018$ $P=.79$
Work status	$r=0.072$ $P=.28$	$r=0.033$ $P=.62$
Income level	$r=-0.132^*$ $P=.05$	$r=0.124$ $P=.06$
Living status	$r=0.083$ $P=.22$	$r=0.060$ $P=.35$
Attitude towards technology	$r=0.220^*$ $P<.001$	$r=0.223^*$ $P<.001$
Fear of COVID-19	$r=-0.291^*$ $P<.001$	$r=-0.303^*$ $P<.001$
Perceived health	$r=-0.088$ $P=.19$	$r=-0.119$ $P=.07$

*Correlation is significant at the 0.05 level (2-tailed).

Linear regression

A multiple linear regression analysis was conducted to predict the intention to use a symptom app based on age, income level, attitude towards technology, fear of COVID-19 and perceived health. The final model included the predictors attitude towards technology, fear of COVID-19, and age ($F=12.012$; $P<.001$). The model has an r^2 of 0.141. It contains three factors that affect the intention to use, but only two of them are significant predictors:

- Fear of COVID-19, $\beta=-.272$, $t=4.305$, $P<.001$;
- Attitude towards technology, $\beta=.222$, $t=3.532$, $P=.001$;
- Age, $\beta=.107$, $t=1.691$, not significant ($P=.09$).

Another multiple linear regression analysis was conducted to predict the intention to use a tracing app based on age, income level, attitude towards technology, fear of COVID-19 and perceived health. The final model included the predictors attitude towards technology, fear of COVID-19, and age ($F=14.333$; $P<.001$). The model has a r^2 of 0.155. Intention to use is predicted by:

- Fear of COVID-19, $\beta=.286$, $t=4.742$, $P<.001$;
- Attitude towards technology, $\beta=.230$, $t=3.815$, $P<.001$;
- Age, $\beta=.128$, $t=2.104$, $P<.05$.

Main reason to use the mobile applications

An overview of all reasons the responders brought forth for using both mobile applications is presented in Table 4. The main reason (28.4%) for responders to use the symptom app, was to control the spread of the COVID-19 virus. In addition, respondents were willing to use this mobile application to monitor own complaints (19.0%) and to gain more insight into the spread and symptoms of the COVID-19 virus (16.4%).

The main reason to use a tracing app was also to control the spread of the COVID-19 virus (30.6%). Next to this, respondents were willing to use this mobile application to gain more insight into the spread and symptoms of the COVID-19 virus (23.1%) and for one's own health (12.9%).

Table 4. Overview of the main reasons to use the two mobile applications.

Main reasons to use a symptom app (n=116)		Main reasons to use a tracing app (n=147)	
To control the spread of the COVID-19 virus in general	28.4%	To control the spread of the COVID-19 virus in general	30.6%
To monitor own complaints	19.0%	More insight into the spread and symptoms of COVID-19	23.1%
More insight into the spread and symptoms of COVID-19	16.4%	For one's own health	12.9%
To control the spread of the COVID-19 virus for oneself	12.9%	For safety	11.6%
For one's own health	10.3%	To control the spread of the COVID-19 virus for oneself	10.2%
For safety	6.0%	For society	6.1%
For society	4.3%	To protect the frail population	4.1%

To protect the frail population	1.7%	Out of fear	1.4%
Out of fear	0.9%		

Main reason not to use the mobile applications

An overview of the reasons not to use the mobile applications is presented in Table 5. For both mobile applications, privacy was mentioned as the main reason (symptom app=55.7% and tracing app=64.8%) not to use the mobile applications. Other reasons for not using the mobile applications were the expected usefulness of the application (symptom app=23.5% and tracing app=13.4%) and a fear of becoming over aware of the situation and its potential consequences, leading to unnecessary stress (symptom app=7.8% and tracing app=11.3%).

Table 5. Overview of the main reasons **not** to use the two mobile applications.

Main reasons to use a symptom app (n=113)		Main reasons not to use a tracing app (n=142)	
Privacy / not willing to share information with government	55.7%	Privacy / not willing to share information with government	64.8%
Doubting usefulness	23.5%	Doubting usefulness	13.4%
Over awareness / stress	7.8%	Over awareness / stress	11.3%
Doubting ease of use	4.3%	No (compatible) phone	4.2%
Doubting security	4.3%	Doubting security	2.1%
No (compatible) phone	1.7%	Doubting ease of use	2.1%
The fear the use of the app will be forced by government	0.9%	The fear the use of the app will be forced by government	2.1%

Discussion

The aim of this paper was to identify antecedents of acceptance of 1) a mobile application for COVID-19 symptom recognition and monitoring, and 2) a mobile application for contact tracing among Dutch citizens by means of an online survey.

Principal Results

Our main finding is that for both mobile applications age, attitude towards technology and fear of COVID-19 are antecedents of acceptance. A large group of the Dutch citizens (45.3%) is willing to use a mobile application for COVID-19 symptom recognition and monitoring. The main reasons to use this mobile application are: 1. To control the spread of the COVID-19; 2. To monitor their own complaints; and 3. To gain more insight into the spread and symptoms of the COVID-19 virus. For the case of a mobile application for COVID-19 contact tracing, 41.2% of the Dutch adults appears to be willing to use this mobile application. The main reasons for use are: 1. To control the spread of the COVID-19 virus; 2. To gain more insight into the spread and symptoms of the COVID-19 virus; and 3. For their own health. Privacy, doubting the usefulness of the mobile application and a fear of becoming over aware of the situation and its potential consequences, leading to unnecessary stress are the main reasons not to use the mobile applications. Overall, Dutch citizens were more willing to use a mobile application for COVID-19 symptom recognition and monitoring compared to a mobile application for contact tracing.

Comparison with Prior Work

It is difficult to relate our findings to the existing literature, as limited technology acceptance studies have focused on mobile applications to be used during a pandemic, and insights on factors that determine the acceptance of COVID-19 related mobile applications are lacking [7]. In general, age and attitude towards technology are widely-acknowledged antecedents of acceptance. For age there is evidence that older age is associated with lower level of acceptance of mobile applications [13]. Previous results also indicated that attitude towards technology is an important antecedent of acceptance of mobile applications [13, 14]. The degree to which an individual is willing to try out any new mobile application is related to the intention to use [13]. Since this study, the mobile applications, announced by the Dutch Government in April 2020, have been developed and implemented. In a recent study by Bente et al., 2021 [15], the contact tracing app (the CoronaMelder) was tested for usability, and was found easy to use. A comparable study was executed in Germany by Blom et al., 2021 [16]. They analysed the potential barriers for the large-scale adoption of the official contact tracing app that was introduced in Germany. The foremost barriers towards using the contact tracing app was the lack of willingness to correctly adopt the app. Besides, compared to the younger group (aged 18-59 years) the older age group (aged 60-77 years) were less likely to use a compatible smartphone. Therefore also access was mentioned as barrier in this study [16]. Another cross-country survey study (participating countries: France, Germany, Italy, the UK and the USA) on the acceptance of a contact-tracing app is more optimistic [17] as the willingness to install the app is high among all five countries and across all subgroups of the population. In addition, this study concluded that epidemiological evidence shows that app-based contact tracing can suppress the spread of COVID-19 if a high enough proportion of the population uses the app [17].

Our results show that fear of COVID-19 is the most important COVID-19-related factor that predicts acceptance of mobile applications to deal with the COVID-19 pandemic. Since it is difficult to translate this fear into technology design, this finding needs to be seen in a bigger picture. Public health campaigns during the COVID-19 epidemic will need to educate citizens about the dangers of COVID-19 (personally and for society as a whole), and should then offer downloading COVID-19 mobile applications as a personal strategy to deal with this fear. Next, the positive attitude towards technology that precedes a decision to download a COVID-19 app should be taken into consideration when using these innovations. The end-user population might be skewed towards those with interest in technology (traditionally these are younger, highly-educated men [18]) which can create a use divide, and thus, a health divide in society. Measures should be installed to support those groups in society that are not, by nature, technically interested, like promotional stalls in the community and diverse channels of user support.

Limitations

The following four limitations should be taken into account for this study. First, due to our recruitment method (snowball sampling via social media) our sample could have been affected by a selection bias. Our sample was mainly composed of participants with a high educational level and a moderate attitude towards technology. Therefore, our results are based on the views of a somewhat skewed sample of the Dutch population, which might reduce the generalizability of our findings. Second, for our analysis the power of our sample was sufficient. However, a larger sample would improve the generalizability of our outcomes as mainly Dutch citizens from the eastern part of the Netherlands (87% of our sample) completed our survey. Third, in our survey the two mobile applications are introduced by means of a short description of their general aim. It is unclear if this description was sufficient for the responders to understand the purpose of both mobile applications. Our survey was distributed before the development of the CoronaMelder in the Netherlands. The study of Bente et al., 2021 [15] learned us that during this period there were many misconceptions concerning contact tracing among the Dutch population. It is likely that these short descriptions of

the general aim of the two mobile apps was insufficient to take those misconceptions away. Fourth, the explained variance of both our models is relatively low. Normally, in studies such as these, this number is boosted by including the predictors perceived ease of use and perceived usefulness. However, including these two factors leads to little practical results, i.e. concluding that the applications should be easy to use is a given. On the other hand, the identification of COVID-19-related factors are an important extension of the existing technology acceptance models.

Conclusions

Age, attitude towards technology and fear of COVID-19 are important predictors of the acceptance of COVID-19 mobile applications for symptom recognition and monitoring and for contact tracing. These predictors should be taken into account during the development and implementation of these mobile applications to secure acceptance.

Acknowledgements

The survey was developed by SJK, MH and LvV. Statistical analyses were performed by SJK and LvV. All authors were involved in the distribution of the survey and participated in drafting the article and revising it critically for important intellectual content.

Conflicts of Interest

None declared.

Abbreviations

COVID-19: Coronavirus disease 2019

SD: Standard deviation

Multimedia Appendix 1

Table 6. Survey questions and answer options in Dutch and English. (D= demographic questions / C= fear of COVID-19 questions / H= perceived health questions / TAM-BI= behavioural intention)

		Dutch		English	
D	1	Wat is uw geslacht?	o Man o Vrouw	What is your gender?	o Men o Women
D	2	Wat is uw leeftijd?		What is your age?	
D	3	Wat zijn de 4 cijfers van uw postcode?		What are the 4 digits of your zip code?	
D	4	Heeft u een smartphone?	o Ja o Nee	Do you have a smartphone?	o Yes o No
D	5	Draagt u uw smartphone de hele dag bij u?	o Nooit o Soms o Altijd	Do you carry your smartphone with you all day?	o Never o Sometimes o Always
D	6	Wat is de hoogste opleiding die u heeft afgerond?	o Basisschool o Lbo, mavo, vmbo	What is the highest level of education you	o Primary school o vocation

			<input type="radio"/> Mbo, havo, vwo <input type="radio"/> Hbo, wo <input type="radio"/> Ik studeer nog	have completed?	<input type="radio"/> education <input type="radio"/> vocational education <input type="radio"/> higher education <input type="radio"/> I am still studying
D	7	Welke van de volgende categorieën beschrijft uw werkstatus het best?	<input type="radio"/> Werkloos, op zoek naar werk <input type="radio"/> Werkloos, niet op zoek naar werk <input type="radio"/> Part-time werkzaam <input type="radio"/> Full-time werkzaam <input type="radio"/> Gepensioneerd <input type="radio"/> Door ziekte niet de mogelijkheid om te werken <input type="radio"/> Student <input type="radio"/> Vrijwilligerswerk	Which of the following categories best describes your work status?	<input type="radio"/> Unemployed, looking for work <input type="radio"/> Unemployed, not looking for work <input type="radio"/> Working part-time <input type="radio"/> Working full-time <input type="radio"/> Retired <input type="radio"/> Not able to work due to illness <input type="radio"/> Student <input type="radio"/> Volunteering
D	8	Wat is uw gemiddelde inkomen? (Modaal inkomen = €36.000 bruto per jaar)	<input type="radio"/> Beneden modaal <input type="radio"/> Rond modaal <input type="radio"/> Boven modaal	What is your average income? (Average income = € 36,000 gross per year)	<input type="radio"/> Below average <input type="radio"/> Around average <input type="radio"/> Above average
D	9	Bent u alleen of woont u samen?	<input type="radio"/> Alleenstaand <input type="radio"/> Samenwonend <input type="radio"/> Anders	Are you single or do you live together?	<input type="radio"/> Single <input type="radio"/> Living together <input type="radio"/> Otherwise
D	10	Hoe denkt u over nieuwe technologieën in het algemeen? Vink voor elke stelling het antwoord aan dat het beste bij u past.	How do you feel about new technologies in general? For each statement, tick the answer that suits you best.		
		a. Als ik hoor over een nieuwe technologie, kijk ik ernaar uit om dat uit te proberen	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	a. When I hear about a new technology, I look forward to trying it out	<input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
		b. Vergeleken met de mensen in mijn omgeving ben ik meestal een van de	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	b. Compared to the people around me, I'm usually one of the first to try	<input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree

		eersten die nieuwe technologieën uitprobeert		out new technologies	<input type="radio"/> Strongly agree
		c. In het algemeen aarzel ik om nieuwe technologieën uit te proberen	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	c. In general, I hesitate to try out new technologies	<input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
		d. Ik probeer graag nieuwe technologieën uit	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	I like to try out new technologies	<input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
D	11	Bent u al besmet geraakt met het COVID-19 virus?	<input type="radio"/> Ja <input type="radio"/> Nee <input type="radio"/> Ik twijfel	Have you already been infected with the COVID-19 virus?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> I doubt
C	12	Was u de afgelopen weken bezorgd over de uitbraak van het COVID-19 virus?	<input type="radio"/> Helemaal niet bezorgd <input type="radio"/> Een klein beetje bezorgd <input type="radio"/> Nogal bezorgd <input type="radio"/> Bezorgd <input type="radio"/> Heel erg bezorgd	Have you been concerned about the outbreak of the COVID-19 virus in recent weeks?	<input type="radio"/> Not at all concerned <input type="radio"/> Slightly concerned <input type="radio"/> Somewhat concerned <input type="radio"/> Moderately concerned <input type="radio"/> Extremely concerned
C	13	Hoe vaak dacht u de afgelopen weken aan de uitbraak van het COVID-19 virus?	<input type="radio"/> Nooit <input type="radio"/> Zelden <input type="radio"/> Soms <input type="radio"/> Vaak <input type="radio"/> Altijd	How often did you think of the outbreak of the COVID-19 virus in recent weeks?	<input type="radio"/> Never <input type="radio"/> Rarely <input type="radio"/> Sometimes <input type="radio"/> Often <input type="radio"/> Always
C	14	Hoe bang was u de afgelopen weken voor de uitbraak van het COVID-19 virus?	<input type="radio"/> Helemaal niet bang <input type="radio"/> Een klein beetje bang <input type="radio"/> Nogal bang <input type="radio"/> Bang <input type="radio"/> Heel erg bang	How scared were you of the outbreak of the COVID-19 virus in recent weeks?	<input type="radio"/> Not afraid at all <input type="radio"/> A little bit afraid <input type="radio"/> Quite afraid <input type="radio"/> Scared <input type="radio"/> Very scared
C	15	Hoe bang bent u om ziek te worden van het COVID-19 virus?	<input type="radio"/> Helemaal niet bang <input type="radio"/> Een klein beetje bang <input type="radio"/> Nogal bang	How afraid are you of getting sick from the COVID-19 virus?	<input type="radio"/> Not afraid at all <input type="radio"/> A little bit afraid <input type="radio"/> Quite afraid

			o Bang o Heel erg bang		o Scared o Very scared
H	16	Hoe zou u uw gezondheid omschrijven?	o Slecht o Matig o Goed o Zeer goed o Uitstekend	How would you describe your health?	o Bad o Poor o Good o Very good o Excellent
H	17	Hoe bezorgd bent u over uw gezondheid?	o Helemaal niet bezorgd o Een klein beetje bezorgd o Nogal bezorgd o Bezorgd o Heel erg bezorgd	How concerned are you about your health?	o Not at all concerned o Slightly concerned o Somewhat concerned o Moderately concerned o Extremely concerned
H	18	Ik ben vaker ziek dan andere mensen van dezelfde leeftijd en hetzelfde geslacht.	o Zeer mee oneens o Mee oneens o Neutraal o Mee eens o Zeer mee eens	I am sick more often than other people of the same age and gender.	o Strongly disagree o I disagree o Neutral o Agree o Strongly agree
TAM M	19	Hieronder krijgt u stellingen die gaan over uw verwachting over de app waarmee in kaart wordt gebracht met wie een besmet persoon in contact is geweest. Vink voor elke stelling het antwoord aan wat het best aan uw verwachting voldoet.		Below you will find statements about your expectation about the app to determine if an infected person has been contacted with others. For each statement, tick the answer that best meets your expectations.	
TAM-BI		a. Ik ben van plan deze App te gebruiken zo vaak als nodig is.	o Zeer mee oneens o Mee oneens o Neutraal o Mee eens o Zeer mee eens	a. I plan to use this App as often as necessary.	o Strongly disagree o I disagree o Neutral o Agree o Strongly agree
		b. Als deze App beschikbaar zou zijn voor mij, zou ik deze absoluut gebruiken.	o Zeer mee oneens o Mee oneens o Neutraal o Mee eens o Zeer mee eens	b. If this App were available to me, I would absolutely use it.	o Strongly disagree o I disagree o Neutral o Agree o Strongly agree
		c. Ik hoop dat deze App beschikbaar komt voor mij.	o Zeer mee oneens o Mee oneens o Neutraal o Mee eens o Zeer mee eens	c. I hope this App becomes available to me.	o Strongly disagree o I disagree o Neutral o Agree o Strongly agree

	20	Wat is voor u de belangrijkste reden om gebruik te maken van deze App?	What is the main reason for you to use this App?
	21	Wat is voor u de belangrijkste reden om geen gebruik te maken van deze App?	What is the main reason for you not to use this App?
TAM	22	Hieronder krijgt u stellingen die gaan over uw verwachting over de app om symptomen van u, als eventuele corona patiënt, te volgen. Vink voor elke stelling het antwoord aan wat het best aan uw verwachting voldoet.	Below you will find statements about your expectation about the app to track your symptoms as corona patient. For each statement, tick the answer that best meets your expectations.
TAM-BI	a. Ik ben van plan deze App te gebruiken zo vaak als nodig is.	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	a. I plan to use this App as often as necessary. <input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
	b. Als deze App beschikbaar zou zijn voor mij, zou ik deze absoluut gebruiken.	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	b. If this App were available to me, I would absolutely use it. <input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
	c. Ik hoop dat deze App beschikbaar komt voor mij.	<input type="radio"/> Zeer mee oneens <input type="radio"/> Mee oneens <input type="radio"/> Neutraal <input type="radio"/> Mee eens <input type="radio"/> Zeer mee eens	c. I hope this App becomes available to me. <input type="radio"/> Strongly disagree <input type="radio"/> I disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree
	23	Wat is voor u de belangrijkste reden om gebruik te maken van deze App?	What is the main reason for you to use this App?
	24	Wat is voor u de belangrijkste reden om geen gebruik te maken van deze App?	What is the main reason for you not to use this App?

References

1. Fang L, Karakiulakis G, Roth M. Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? *The Lancet Respiratory Medicine*; 2020;8(4):e21.
2. Roux J, Massonnaud C, Crépey P. COVID-19: One-month impact of the French lockdown on the epidemic burden. *medRxiv*; 2020.
3. Di Domenico L, Pullano G, Sabbatini CE, Boëlle P-Y, Colizza V. Impact of lockdown on COVID-19 epidemic in Île-de-France and possible exit strategies. *BMC Med*; 202; 18: 240
4. Krausz M, Westenberg JN, Vigo D, Spence RT, Ramsey D. Emergency Response to COVID-19 in Canada: Platform Development and Implementation for eHealth in Crisis Management. *JMIR public health and surveillance*; 2020;6(2):e18995.
5. Ferretti L, Wymant C, Kendall M, Zhao L, Nurtay A, Abeler-Dörner L, et al. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. *Science (New York, NY)*; 2020;368(6491):eabb6936.

6. Hinch R, Probert W, Nurtay A, Kendall M, Wymant C, Hall M, Lythgoe K, Cruz AB, Zhao L, Stewart A, Ferretti L. Effective configurations of a digital contact tracing app: a report to NHSX. Retrieved July. 2020 Apr 16;23:2020.
7. Thorneoloe R, Epton T, Fynn W, Daly M, Stanulewicz N, Kassianos A, Shorter GW, Moll SJ, Campbell M, Sodergren S, Chapman S. Scoping review of mobile phone app uptake and engagement to inform digital contact tracing tools for COVID-19. PsyArXiv; 2020.
8. Anderson K, Burford O, Emmerton L. Mobile health apps to facilitate self-care: a qualitative study of user experiences. PLoS One; 2016;11(5):e0156164.
9. Agarwal R, Prasad J. A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. Information Systems Research; 1998;9(2):204-15.
10. van Velsen L, Beaujean DJMA, van Gemert-Pijnen JEW, van Steenberghe JE, Timen A. Public knowledge and preventive behavior during a large-scale Salmonella outbreak: results from an online survey in the Netherlands. BMC public health; 2014;14(1):100.
11. van Velsen L, van der Geest T, van de Wijngaert L, van den Berg S, Steehouder M. Personalization has a Price, Controllability is the Currency: Predictors for the Intention to use Personalized eGovernment Websites. Journal of Organizational Computing and Electronic Commerce; 2015;25(1):76-97.
12. [Internet] [cited 2021 Nov 2]. Available from: <https://opendata.cbs.nl>
13. Rai A, Chen L, Pye J, Baird A. Understanding Determinants of Consumer Mobile Health Usage Intentions, Assimilation, and Channel Preferences. Journal of medical Internet research; 2013;15(8):e149.
14. Hussein Z, Oon SW, Fikry A. Consumer Attitude: Does It Influence the Intention to Use mHealth? Procedia Computer Science; 2017;105:340-4.
15. Bente BE, van 't Klooster JWJR, Schreijer MA, Berkemeier L, van Gend JE, Slijkhuis PJH, et al. The Dutch COVID-19 Contact Tracing App (the CoronaMelder): Usability Study. JMIR Form Res; 2021;5(3):e27882-e.
16. Blom AG, Wenz A, Cornesse C, Rettig T, Fikel M, Friedel S, et al. Barriers to the Large-Scale Adoption of a COVID-19 Contact Tracing App in Germany: Survey Study. Journal of medical Internet research; 2021;23(3):e23362.
17. Altmann S, Milsom L, Zillesen H, Blasone R, Gerdon F, Bach R, et al. Acceptability of App-Based Contact Tracing for COVID-19: Cross-Country Survey Study. JMIR Mhealth Uhealth; 2020;8(8):e19857.
18. Rojas-Méndez José I, Parasuraman A, Papadopoulos N. Demographics, attitudes, and technology readiness: A cross-cultural analysis and model validation. Marketing Intelligence & Planning; 2017;35(1):18-39.

Supplementary Files