Vrije Universiteit Amsterdam

Universiteit van Amsterdam

Master Thesis

Engaging Public Directly and Actively Reporting Health Data through mHealth Technologies

Author: Siying Zhang (2611811)

1st supervisor:	Anna Bon
daily supervisor:	The Network Institute Amsterdam
2nd reader:	Hans Akkermans

A thesis submitted in fulfillment of the requirements for

the joint UvA-VU Master of Science degree in Computer Science

August 18, 2020

"I am the master of my fate, I am the captain of my soul"
from Invictus*, by William Ernest Henley*

Abstract

With the emergence of COVID-19 outbreak and the necessity to control COVID-19, real data reported from the general public though mobile-based communication tools plays a critical role in decision making. Public engagement to collect information allows health authorities to capture and explore 'unknow' data. Despite participatory approach has been considered as a cost-effectively way to supplement of existing diseases surveillance, low accuracy of self-reported data and lack of regular and behavioral use is still common in active participatory disease surveillance system. To cope with the questions and fill the gap between design and reality in the context of usage and the lack of empirical evidence, the aim of the study is to investigate how mHealth technologies can effectively support user engagement among accuracy. To give an implication and provide a valuable solution, case studies have been conducted in the context of China and the Netherlands. Based on a case study meant to learn about user needs and making use of participatory design as a design approach, a conceptual design will be derived that serves as a blueprint for COVID-19 response.

Acknowledgements

I would like to extend my deepest gratitude to my supervisor, Bon Anna, for hers unparalleled support either for the study or my personal life. Due to unexpected family obligations, the research had to be conducted remotely. With hers profound belief in my work, I could finish the research smoothly. I'd also like to extend my gratitude to Ona Ilozumba and Lisanne van Lent, especially helpful to me in preparation of the thesis. Although due to the COVID-19, the original project has to be modified.

Moreover, I'd like to acknowledge the assistance of Hella Schaefers, who played a decisive role in bringing me into contact with some health experts in the Netherlands. Thanks also to all participants in China and the Netherlands, whom share their opinion to me and contribute knowledge on the project.Furthermore, I very much appreciate that Natalia Silvis provided me with encouragement and useful suggestion for my study life. Last but not least, thanks should also go to the Network Institute Amsterdam, who fund the thesis and provided this great opportunity to me.

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Introduction

The battle of humans with infectious diseases experiences a long period of history and the scourge of infectious diseases has not diminished (2). In 2012, researchers also mentioned that with the increase in mobility of the global population, the spread of newly emerging diseases will exceed the pandemics experienced before (3). For low resource settings or countries with high population density, it is difficult to pledge preparing to these emergencies. However, an effective and adequate precaution is a critical and essential component for slow or stop outbreaks.

Currently, thanks not only to advancement of modern science, but also to the increase in the numbers of the adoption of new technologies such as computers and smartphones, health authorities have been supported to confine the epidemic outbreaks. According to a report from Global digital 2019, more than 5 billion unique mobile telephone users across the world (4). The demands of mobile phone-involved prevention have coincided with an increase in both usage of and technological advances in mobile technology. Mobile health (mHealth) is considered as cost effective technologies for health care, which is defined as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" by the Global Observatory for eHealth (GOe) (5).

Such digital response for diseases allow to real time data collection and information communication, which is critical to infectious diseases. Particularly, decision makers need detailed and timely surveillance data, and health authorities are expected to present trustworthy information to increase the awareness of general public and actively response to diseases. Data collection and reporting of infectious diseases are consisted of existing traditional surveillance system. Besides such surveillance predominantly based on general practitioner and laboratory, new approaches to collect and reporting health-related data

have been introduced as a supplement.
One of new approaches is public engagement in voluntary monitoring of disease, namely participatory disease surveillance (6). In the study, we aim to focus on active participatory disease surveillance and such public engagement refers the population at risk actively and directly reporting health status using communication tools. Nearly all demands of communication tools are mobile or internet connectivity, which could encourage the general public to regular and voluntary self-reporting their data. This implies that participants are willingly and knowingly submit information, which offers opportunities to improve diseases surveillance by collecting 'unknow' data.

1.1 Background

1.1.1 Opportunities for Strengthening Disease Surveillance

With an increase in the COVID-19 severity around the world, the shortage of medical supplies has becoming a global and emergency issue. Hence, surveillance data for infectious diseases is an essential component for prevention and control measures, including identifying, tracking and monitoring risk groups. A lot of research and projects had made an effort on adapting mobile technologies in data collection and reporting, which are based on general practitioners. This because surveillance data have a crucial role in decision-making and understanding the spread of pandemic.
However, as we mentioned before, participatory approach allows health authorities to capture 'unknow' data. These 'unknow' data normally are directly generated by the general public, which is shown in the below figure. Traditional diseases surveillance is highly based on the healthcare seeking behaviors (7), (8). As for infectious diseases, the negative medical attention might lead that a highly possibility that the number of cases reported is underestimation. The reasons behind that are complex, which might be inherently biases on socio-demographic differences, disease severity and so on (7).
Moreover, due to the fact that a majority of countries are facing the lack of medical resources against pandemic, such as laboratory-based testing materials and professional practitioners, not all of infected individuals are supposed to get a timely diagnosis and treatment. Such considerable delay potentially threatens other individual's health.
Therefore, capturing data from the general public can be considered as an alternative way for traditional surveillance. Community engagement has been proposed as a direct data provider and this digital engagement not only provides a more comprehensive estimate of disease burden, but also is considered as a less costly and more flexible way.

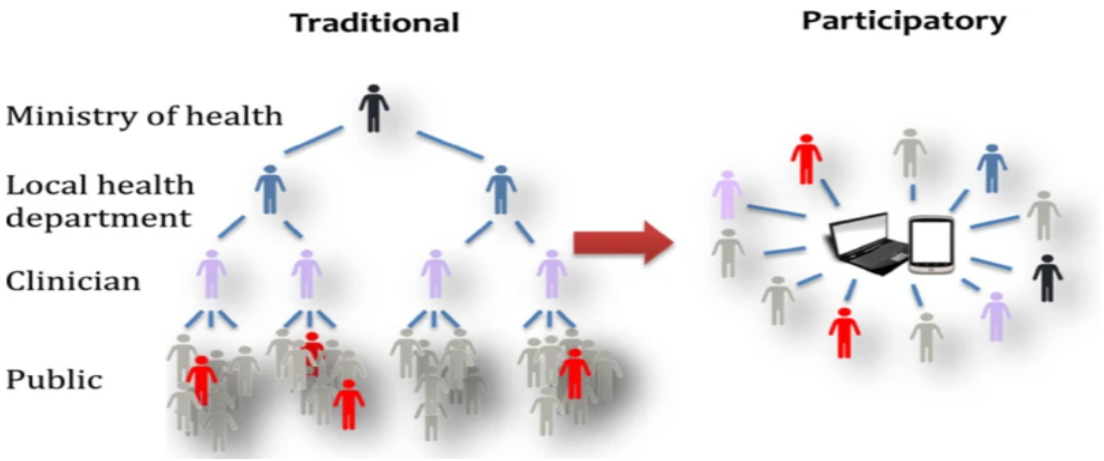

Figure 1.1: Comparison between two methods of surveillance systems (Wójcik et al., 2014)

1.1.2 COVID-19 Response and Challenges

As a novel coronavirus infection in 2019, up to the 1st of April in 2020, the outbreak of coronavirus disease (COVID-19) killed over 400,000 people and more than 850 thousand or more victims worldwide (9). To prevent the number of infected cases and saving lives, WHO proposed a guidance for public health and social measure to slow or stop the spread of COVID-19 (10). Alongside social distancing, detection and management of people who have may been exposed to an infectious agent or disease, such as ill travelers from at-risk countries, is being necessary and important. The Figure 1.2 shown below represent that new countries reporting COVID-19 cases has nearly tripled in two months, making early intervention all the more critical. The reasons of this phenomena are not only because travelling could significantly increase the likelihood of new chains of transmission of COVID-19 from appearing, but also due to the lack of control on people exposing to an infectious agent or disease. This poses a threat to the whole country, especially for low resource settings or countries with high population density. Facing this issue, many countries have taken actions into monitoring the outbreak of COVID-19, and some of countries with limited medical resources or at high risk, decided to lockdown several cities or even a whole country at national level. From the perspective of fighting the pandemic in China, lockdown strategies are brutal but effective in a two months containment phase. However, there are two inevitable challenges:

- A challenge for economy: the economy suffers heavy losses, which might lead to economic recession, especially for the developing world, due to a significantly negative influence on personal life, tourist industry and international trade.

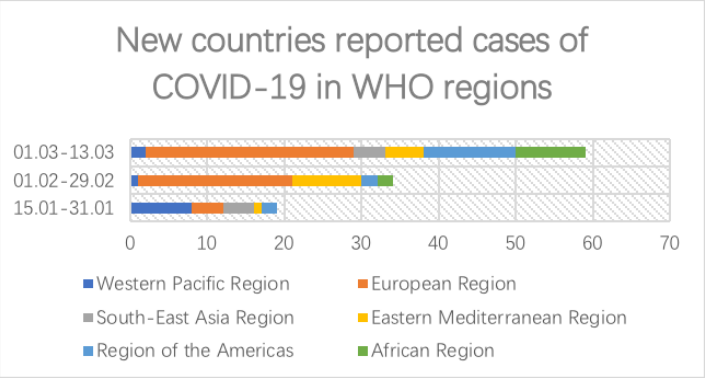

Figure 1.2: New countries reported cases of COVID-19

- A challenge for workforce: Prevention and control will be a daily routine for the public in a long term unless vaccines or other effective measures are available. China and Korea, having an effective measure on COVID-19, are stepping up multiple measures to strictly prevent the import of overseas epidemics. For instance, enhanced quarantines and testing passengers are supported in national level, which leads that the workforce of health systems has been overwhelmed, especially for hospital and health-care workers (3).

1.1.3 Target Group

In the study, we consider people with higher concerns of COVID-19. In other words, people who have may been exposed to an infectious agent or diseases and think they are possibly infected. To be more specific, we divided target group into three subgroups according to the possibility to contact with confirmed cases and the risk of coronavirus.

- People who closely contact with suspected or confirmed cases
- Travelers from high-risk countries or areas
- People who are working at or in a hospital
- People aged 50 and over

Both inbound travelers are at relevant high risk because they are exposed themselves to a confined space in airplane, cruise. As for people who are working at hospital (e.g. health related workers, security personnel) and people who are staying at hospital, especially for hospital attendant, there is a high possibility to expose to suspected or confirmed cases but without awareness in a designated hospital for COVID-19. According to the report (11), the death rate for people aged 50 and over becomes increasing, and therefore we suppose that people at this age group will have more concerns than other age groups. Due to the fact that it is problematic that having a contract with first three groups as participants

during the outbreak of COVID-19, we aimed to people aged 50 and over as our target participants.

1.2 Research Question

Following the problem statement, the goals of the research are to investigate if the mHealth technologies can be used to strengthen the surveillance data through participatory approach in China and whether the result is also useful for the Netherlands. To achieve the stated purpose, the Main Research Question (MRQ) arises:

- MRQ1: How can mHealth technologies efficiently support self-reporting for people with higher concerns of COVID-19, with observations from China and Netherlands?
  - How are people with higher concerns of COVID-19 currently doing for reporting their health status?
  - What are user preferences that facilitate submitting accuracy health data for mobile based self-reporting tools?
  - What are the features of mobile-based self-reporting tools that facilitate its behavioral and regular use?
- MRQ2: How do the factors above vary across countries?

By identifying and understanding the interests of Chinese and Dutch community in mHealth solution for self-reporting, we are intended at providing a valuable solution to other countries combating COVID-19.

1.3 Research Scope

Given the demands of response and serve better in local area for fighting with COVID-19, a lot of efforts have already paid on traditional approach to data collection. In this research, the general goal is bounded to participatory diseases surveillance systems, which contains directly knowledge of the user.
The specific goal is limited to active-based method, and we only focus on analyzing mobile applications in improving the public engagement among accuracy for self-reporting behavior. Furthermore, since the different scenarios will have different prevention and control guidelines. We only investigate the user needs and requirements within observations of China and the Netherlands.

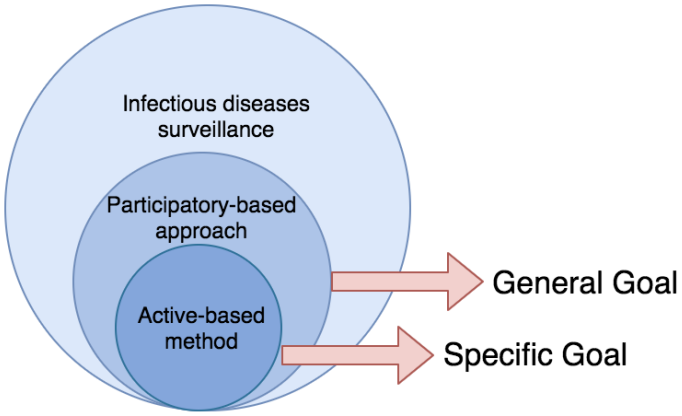

Figure 1.3: The overview of research scope

1.4 Research Method

1.4.1 ICT4D 3.0 Framework

The study sought to solve the research questions related a high context dependent setting. This requires researchers to heavily collaboration with local users, experts and stakeholders. Therefore, we followed ICT4D 3.0 field research methodology (12), as a theoretical framework. The cultural, geographical or even language challenges are common exists between developer and local communities. This framework is an evidence-based guideline for helping developers to design ICT systems and services through considering user as central position. There are five stages included in the framework: namely, Context Analysis, Needs Assessment, Requirements Analysis, Engineering Deploying Evaluation and Sustainability Assessment.

The ICT4D 3.0 framework has been slightly considered as a guideline for constructing the research. However, the study has more concerns on obtaining much knowledge and attitudes that participants provided on technology acceptance. Instead of performing sustainability assessment, comparison between two different countries has been introduced. The Figure 1.4 illustrates a detail insight about the flow of the research and how each phase will be constructed.

1.4.2 Context Analysis

As proposed before, we aimed to focusing on self-reporting combating COVID-19 in the context of China and the Netherlands. Hence, it was necessary to gain much knowledge

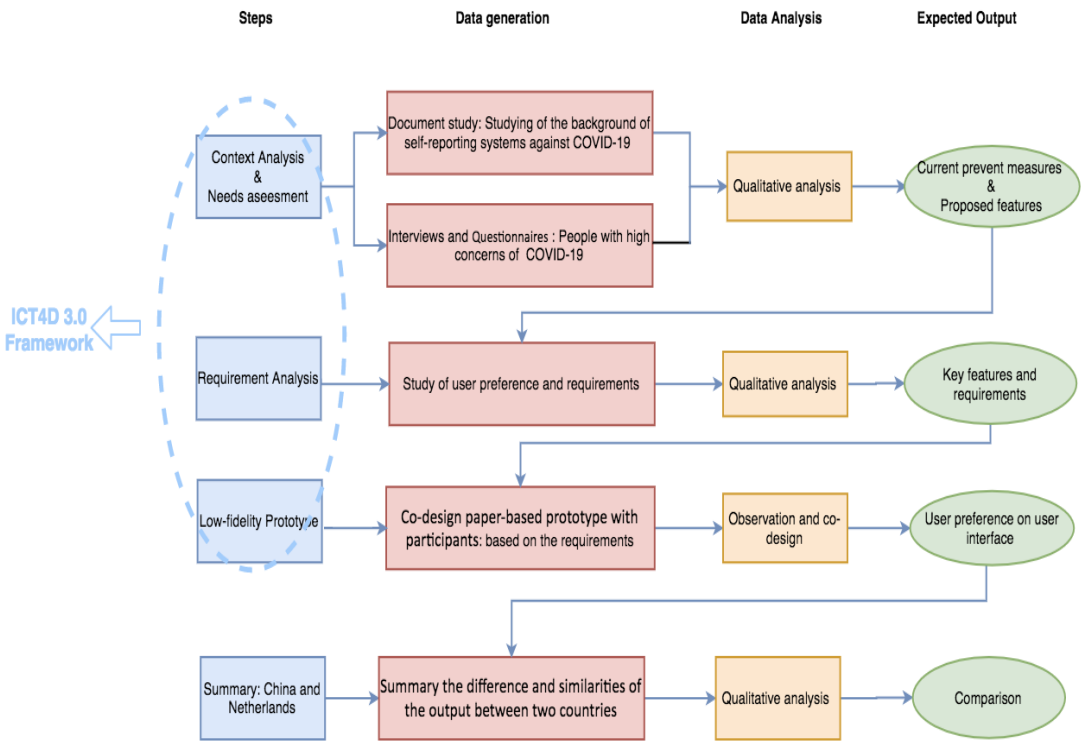

Figure 1.4: The overview of research process

about local context. To bridge the gap between technical developers and users, context analysis must be explicit by two aspects, namely the current situation of ICT and coronavirus. By analysing and investigating documents from World Health Organization (WHO) and local government authorities for target countries and field visiting, we could have a more clearly understand for a real-life situation.

1.4.3 Need Assessments

As soon as the local context becomes concrete and clear, need assessment will be processed. During the section of need assessment, there were three iterative steps that need to be completed for knowledge sharing. And this will be done through semi-structure interview, survey and group discussion. The different stakeholders will be asked in a semi-structured manner within a half hour. Specifically, each participant is expected to answer questions in terms of their concerns, proposing missing requirements and feasible solutions.

- Elicitation and definition of the problem space: Identifying and learning about current concerns and measures on prevention of coronavirus disease from local people.

- Exploration of possible solution: With the identification of existing constraints, the possible solutions have been proposed by participants.

1.4.4 Requirement Generation

When user needs had been collected, this stage needed to translating user needs into the requirements for further development process by use case. Following, requirements, functional and non-functional requirements that must have to meet users' needs could be generated. In additional, based on the list of requirements generated, we have an implication on design decision making.

1.4.5 Low-fidelity prototype

The low-fidelity prototype will be co-design with participants. In such participatory design, participants were encouraged to actively express their idea with paper-based prototype in a democratic way (13). This supports us to clearly and directly investigate what user preferences are. In this context, the role of participants transforms from users to co-designers, and collaboration with target people is created. The aim of involving potential users is to explore the answers from users' perspective about "what should the application be look like?" and "how would I use the system?" (14). Furthermore, participatory approach is highly context dependent (15), which facilities the development of mobile application in healthcare condition. The process involves two steps:

- Steps 1: Observation.
  Six senior citizens were invited to perform predefined tasks to explore and learn about the difficulties and preference that they met when using the mobile application.

- Steps 2: Storyboard Participants were allowed to brainstorm and free to express their idea about mobile applications appearance for participatory coronavirus application. Participants were encouraged to create a set of interfaces for the features that were generated by the results of need assessments. Since common low literacy and less experience about the adoption of mobile application among older generation, the researcher will help to guide design through drawing boards of blank mobile phones and ask questions, " Is there anything that you want to improve or change about the design? And how would you like to improve or change?" Therefore, how application interacts with envisaged users in a sequential order based on their preference has been identified.

2

Context Analysis

In this chapter, we descried a general understanding in the context of two countries. Context analysis was conducted on two aspects: (i) investigating current situation on ICT; (ii) analysing current situation on coronavirus disease.

2.1 ICT in China and the Netherlands

Information and communication technology (ICT) has been considered as a crucial role for facilitating the development of economy, society and infrastructure. Until the year of 2018, internet coverage has reached 64.5% in China (16), however it was still comparative lower than the Netherlands, 93% (17). More specifically, there were less half of internet coverage and roughly three fifth of non-internet users in the rural regions of China, and only 6.7% of internet users over 60 ages, which accounted for 23.6% of the total of people aged 60 and over (16).

During the Netherlands and mainland China's coronavirus epidemic, the demand of digital solutions for supporting normal life including education and health care has been increased. For instance, postponing the opening of campus has been required in a national level and teaching activities compulsory switched to online.

However, the imbalance of internet development, which comes into being a digital gap in China. Students living in remote areas or without devices to access to internet have faced challenges to learn knowledge as the same as other classmates do. Moreover, mobile in combination with internet are currently a major popular way to access to epidemic information for young generation in China. However, elderly adults have meet difficulties about getting information. Traditional media they used like TV and news paper had update latency on broadcasting news, which causes elderly people to make an improper decision on

their behavior. Therefore, the knowledge gap between young and old generation has been expanded.

Furthermore, due to the lack of medical resources and large population, online "real-name system" and "appointment system" registration comprehensively has been implemented in China. Health seeking behavior is based on digital skill, which increases the difficulty for people with less experience on mobile and internet technologies. However, inn the Netherlands, voice call and video call for consulting general practitioners has been considered as a main way in order to reduce the risk of infected among hospitals.

2.2 From Pandemic to Post-COVID-19 World

In order to maximum containment of COVID-19, Chinese government and Dutch governments have adopted different degrees of intervention. Compared to the Netherlands, China has more aggressive measures. As known as, the first confirmed case of COVID-19 was identified in mainland China, on 7th January 2020 (11). This was the time in celebration of the upcoming Chinese Lunar Year. The province of Hubei that raised a warning of further epidemic in a national level was firstly imposed by extreme draconian movement restrictions on 23 January 2020 (18). People with suspected symptoms and who are the close contract with confirmed cases were centralized quarantine and treatment on 2 February. However, with a massive human movement, the numbers of new cases increased exponentially and the cumulative number of confirmed numbers had arrived over 80000 within two months in mainland China. subsequently, door-to-door investigation among community members has been conducted (19). Until 6 March 2020, the number of new cases has significantly dropped to under one hundred in China (20).

Similarly, 23 February was the time in a two-day celebration of Carnival in the Netherlands. And until 23 March, the government announced 'intelligent lockdown' to prevent infection by mass gathering (21). The test population was expanded on 6 April (22).The spread of coronavirus in the Netherlands was slow down around two months and the total number of confirmed cases were over 50000 (23). Overall, it demonstrated that the public health intervention including movement restrictions and intensified surveillance measures that have taken place played a positive role on controlling coronavirus.

Although the containment phase of the outbreak has succeed in China and the Netherlands, the potential second wave of coronavirus is being threatening in the Post-COVID-19 World. In fact, several cities including Beijing, the capital of China, and Jilin city, have found the outbreak within mass gathering in China (20) (24) (25). Similarly, The Figure

2.1 illustrated that new cases in the Netherlands rose after three months of falls.
Moreover, the challenge of imported cases from overseas is being crucial. For many provinces in China, the numbers of imported cases has already exceed the number of domestic confirmed cases (26). To prevent COVID-19 from re-entering the country to cause a new epidemic, a seamless and hermetic process for control and monitoring inbound travellers has been applied in China. Although the number of imported cases were not published in the Netherlands, there is a harsh travel restrictions for inbound travelers to avoid non-essential travel (27). For both countries, movement restrictions including self-isolation and quarantine have been imposed for people who have visited to high risk countries recently (28)(27). Therefore, although both two countries have been successfully shifted from pandemic to Post-COVID-19 World before the July 2020, combating coronavirus will be a long term action until there is an effective vaccine. .

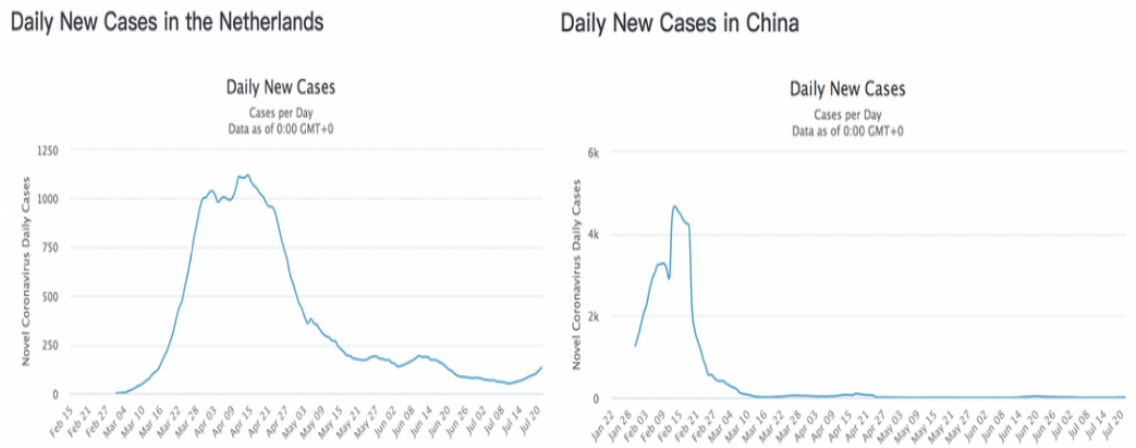

Figure 2.1: Daily New Cases in China and the Netherlands (1)

2.3 Lessons Learned From Context Analysis

The complex and difference local contexts have been introduced in the context of China and the Netherlands in the previous section. We learn about the common concerns and different interests between two countries based-on context analysis.
It is obvious that there is a significant level of low literacy and low digital literacy in China, compared to the Netherlands. With the internet development and lockdown measures implementation, the digital gap between young and older generation has been extended in China. Moreover, both countries have concerns on prevention of potential outbreak in the

2. CONTEXT ANALYSIS

Post-COVID-19 World. Although the numbers of confirmed COVID-19 cases have been reduced and controlled, the possibility of infection caused by mass gathering has significantly could increase after working and studying resumptions. This has been demonstrated in several cities of China. There is an interest in proposing helpful and cost-effective solutions.

3

Need Assessment

Based on the context analysis, mobile health technology has been integrated into residential life in terms of health idea of life and lifestyle. In the section, we learned about how senior citizens protect themselves against coronavirus disease , what current prevention measures based on the involvement of community members by mobile application and what is really important for local people and health workers. To gain an in-depth understanding about whether there are concerns on digital responses and if the possible solution works in the context, interview, online questionnaires and focus group were conducted.

3.1 Attitudes on COVID-19

To explore the answer about what do people think about coronavirus and what do they usually do for prevention coronavirus diseases, online survey with young family members in China, and the interview with five senior citizens in China and three health workers in the Netherlands has been conducted. People at late middle-aged and elderly (50 to 80) were considered as envisaged end-users in China. There were five senior citizens and three health workers participated.

3.1.1 High concerns and voluntary limiting movement in China

The participants from China have expressed that currently they did not feel worried about coronavirus since there was no new confirmed case over a month in the city of Changchun. But they used to pay attention on daily new cases in a national level. And if new cases identified nearby or within the city of Changchun, they would feel more worries. In the time of coronavirus, they used to have high concerns on coronavirus and reducing the times to go outside. All of interviewees also mentioned that if there is no necessary, they only

went to places where they often go. They also persuaded their other family members to stay at home as much as possible during the outbreak. Such movement restriction leads to inconvenient for older adults living separately with their children, and for who has foundation diseases and need to normal health care.
Besides voluntary limiting movement, participants said they would like to wash hands after got home, drink much water and indoor ventilation to prevent infection. However, most of times, they often forget to doing these if there is no one notifying them.

3.1.2 Low concerns and social distance in the Netherlands

According to the conversation with local health workers in the Netherlands, there were less concerns on coronavirus disease compared to people in China. One of General Practitioners (GPs) worked noted that people living in a rural area used to have more concerns on the epidemic and reduce the times of going out.
However, unless voluntary limiting movement in China, there were a lot of people sitting outside next to each other, especially on a sunny day, even in the beginning of outbreak. And this happened a lot within cities in the Netherlands, such as the Hague and Rotterdam. To prevent possible infection, polices have to separate them in the most of cases.
But if people feel uncomfortable, they could call their GP at first and ask for some suggestions and treatments. Unless China, the fever clinics in the Netherlands only accept patients who make an appointment in advance.

3.2 Current Approaches on case detection

We have obtained an general understanding on the attitudes on prevention measures. In this section, the major ways to surveillance through mHealth-based tools that have taken place in China and the Netherlands were analyzed and discussed.

3.2.1 Syndromic surveillance

Surveillance systems can be divided into two ways based on the different types of case detection. A passive case detection is triggered by an actively health seeking behavior by patients, and conversely an active case detection highly relies on front-line health workers.

3.2.1.1 Passive case detection in the Netherlands

According to the conversation with health experts, the work flow from case detection to follow up was summarized. People who have suspect symptoms need to call their local

GPs at first and then the GP will decide whether patients are needed to be referred to the COVID-19 emergency department of hospital. As for, the hospital only receive patients who have calling GP before.

Netherlands has adopted passively case detection, which highly relies on patients' health seeking behavior. Moreover, voice call has becoming a major way to connect with patients remotely in the time of epidemic. If people have mild symptoms, they just need to stay at home until when you are getting better. There is no strict rule and monitoring for people who are close contact. Only for people with serious symptoms but prefer staying at home, doctors will monitor their health condition daily through monitors including measuring oxygen levels. Patients need to record their health data and reports to nurses daily. When the measurement is going worse, patients will be invited to hospital. One of GPs suggested that before going to the hospital, they could go to see patients to make an decision. Such monitors are only applied to people who are seriously sick. Follow up is also adopted to Outpatients to see whether they were well-being, recovered well, and need to be tested for coronavirus.

Moreover, Netherlands has taken a project, called 'infection radar', which allows participants to report their health data once a week. This aim of this project is to learn about how coronavirus develops in the Netherlands, because some of people with mild symptoms and who are close contract are not forced to have a health seeking behavior or share their data. Currently, the numbers of active project users were over 20 thousands (29).

3.2.1.2 Active case detection in China

One of interesting insights is that unlike the Netherlands, the current surveillance systems for COVID-19 in China highly relys on active case detection and public engagement through walk through, hot-line and mobile technologies.

In particular, according to the different target groups, there were two scenarios of mobile phone-based self-reporting systems shown below (Figure **??**). (i) During the outbreak of coronavirus among local communities, government had advocated actively self-reporting behaviors among employees and students. Administrative staffs took charge of remotely monitoring, recording and reporting employees' and students' health conditions daily through mobile technology. However, after work and study resumption, there is no need for updating their health conditions daily and remotely. (ii) With the increase in the numbers of import cases, inbound travellers were required to fill in the health form for 14 consecutive days, which has been regarded as a necessary condition of the entry. To reduce a potential risk of outbreak, people under self-isolation or self-quarantine, needed

to report their health status daily. Relevant community workers traced and monitored people's health conditions in this period to decide whether they could be released from quarantine or isolation (30).

Various technologies for self-reporting have adopted according to the different scenarios. (i) Online health survey from sophisticated mobile phone application was a common way for students, workers and inbound travelers. Besides questions of health status, the questions of recent travel history and close contact was also included. By doing so, without the involvement of medical testing and relevant organizations, potential infected cases could be screened and identified among communities. (ii) Actively sharing health data among group chatting, one of functionalities of WeChat (31). This has becoming an majority way for community workers to collect health status. The most advance of using WeChat group chat is the high penetration in China (32). People were allowed to report their daily health conditions by texting messages or sending a voice record in group. It can reduce the effort and time for data collection compared to paper-based approach. In a chatting group, there is also a function that any group members can send notifications to members who forget to report their data in the group. (iii) Voice call has been adopted, especially for older people or low literacy. But the major problem was the accuracy and timeliness of data due to the poor listening ability and misunderstanding of health questions. However, the workloads of health workers and community workers has increased along with an increase in the period of quarantine or isolation. This because that the government found that several cases with symptoms occurred after 14 days quarantine or isolation. To maximum containment of outbreak, 14 days quarantine in combination with 7 days isolation has been adopted in many regions of China (30).

3.2.2 Tracking System

Apart from active reporting motioned before, passive reporting also has been widely adopted in this section. As for passive reporting, this is normally implemented in association with embedded features of mobile devices or wearable devices.

Invasive tracking systems have been encouraged to control the source of infection around the world including China and the Netherlands. The implementation of tracking application for coronavirus in the Netherlands is still at the stage of technical testing (21). The purpose of application is to inform users if there are confirmed cases nearby under the premise of protecting users' privacy. One of the most concerns is about the motivation for the adoption of such tracking system.

Relatively, China has pioneered the use of the tracking system, health QR code, among

community members. Health QR code is a software code that represents individual's health status according to capturing data in time, spatial and interpersonal dimensions (33). Moreover, health QR code has been adopted to strengthen contact tracing and the management of public through the use of big data and artificial intelligence (AI) in a national scale (30). The algorithms of QR codes used normally includes the various judgement conditions. The categories of conditions required include the degree of epidemic risk, number and time of visiting epidemic areas, and health status and of close contacts separately. Based on data collected and provincial epidemic control database, the different colors (green, yellow, orange and red) will be assigned to indicate people's conditions. If specific conditions are triggered, the yellow, orange or red QR code will be generated, otherwise, the green QR code is identified. Once beginning to use, their relevant data will be passively provided.

Furthermore, it has been applied in public areas including restaurants, shopping malls, public transport and more. Every time when community members enter public space, such dynamic health QR code was required to be displayed to inspectors during the outbreak. Inspectors were allowed to screen people's code through their own mobile, which allows them to easily check and update people's data. After checking the status of health QR code and measuring body temperature, people are allowed to enter. Otherwise, inspectors have a right to refuse entry. The major advantages of the health QR code are helping to screening numerous people quickly and reducing the risk of infection among mass gathering, and collect 'unknown' data without health seeking behaviors.

3.2.3 Current Constraints

In order to investigate constraints on current tools in general, a questionnaire has been conducted, the questionnaires including attitudes on current approaches and self-reporting behavior; The questionnaires were distributed on WeChat, a social platform, and 53 participants provided their answers and ideas.

As the results of questionnaires shown, over half of people aged 50 or over had a positive attitude on actively participating in self-reporting (64%) and contributing their health status data (56%). However, comparing to data collection methods for existing real-name monitoring systems, a majority of people aged 50 or over (68%) preferred providing their information under anonymous. Although 47% of participants thought health QR code is an effective way to control and monitoring the epidemic of coronavirus, there were small numbers of people who's life was negatively effected (23%) and who even do not know why they should use it (23%).

Overall, the concerns identified by questionnaire were (i) people were not willing to provide their information by a real name (ii) existing digital methods have brought some troubles to normal life.

3.3 Willingness on participatory-based system

According to analysing and investigating data captured through interview in the different contexts, the potential solution about how mHealth tools could contribute to current work flows in terms of public engagement was generated.

3.3.1 Low interests in participatory tracking system

When participants were asked whether they want to have a feature for close contract tracking, the participants provided negative answers, and nor community and health workers were interested in it. The reasons were categorized into four aspects:

- Senior citizens unused to use mobile phone as habitually and it is impossible to tracking close contract when mobile phone is placed in their home. One interviewees expressed that he was not used to using his mobile phone frequently, but during the epidemic, he was forced to get used to taking their mobile phone and using it everyday. The reasons was that the motivation of usage mobile phone and mobile application is quite low for senior citizens.

- Senior citizens often rarely go outside in China and there are less places that they often go to compared young generation.

- Potential consequences of using tracking feature could a panic for senior citizens. Taking an example of Health QR code, less people were willing to use the feature of self-reporting when one of suspected symptoms occurs in China. People were afraid that they might be denied to access to everywhere because the color of Health QR code are changed. Such color of code changes without any explanations, which leads to threats among public. What was worse, people would rather traveling without mobile phone to avoid updating their geographical information. Because they were unsure whether symptoms are caused by infection and they knew that if the color of health QR code is changed, they would be limited to movement and this also had negative influence on their close contacts.

- The reliability and accuracy of tracking are significantly important and hard to control. It was noted by one of Dutch interviewee that it is also not feasible for using Bluetooth-based approach to track potential cases. As she said, "if person just passed by someone who might be infected, the risk that you cross is very small." She also took herself as an example to demonstrate that it is will useless for people who are working at hospital because contacting with infected cases is inevitable.

3.3.2 Needs on online health care service

Unlike the Netherlands, patients having symptoms only can be treated in hospitals or clinics in China. There is no family doctor that they can contact with. Sometime, despite they feel uncomfortable or have mild symptoms, staying at home and observe several days are always considered as the first choice. And senior citizens are only willing to go to the hospital, if symptoms cannot be under control or go worse. This because they knew that there is a high possibility of infection in hospital. Moreover, during the outbreak, all the large-scale hospitals in Changchun have implemented the system to make an appointment online for normal health care. Only fever clinics can accept patients who sign up on the spot. However, this makes difficult for senior citizens with less digital skill to have a actively health seeking behavior.

3.3.3 Changing health seeking behavior from offline to online

Although GPs can be accessed by local residents in the Netherlands, there is an demand that changing patients' health seeking behavior through mHealth systems. One of GPs in the Netherlands mentioned that current medical system has too much pressure, and she hopes people could reduce dependence on doctors. But she was also worried about that people will not fill their symptoms right if its potential consequences are related to move restriction or prediction somethings. Another GP introduced an mobile application published by one of hospital in Amsterdam to manage patients through providing treatments from specialist, which has receiving very good reviews and has high adoption. But one downside of the application is that patients could not follow up as good as GP can do.

3.3.4 Improving the efficiency of current data collection

Community workers in China also expressed an interest on mobile application-based data collection tools. This because that although group chatting could facilitate community members to reporting their data instead face-to-face interview and voice call, they still

needed to transfer health information collected from group chatting to a digital form manually and report to relevant organizations daily. Moreover,for each community worker needed to manage more than 300 households to track their data in twice a day through group chatting. We assumed that collecting data from one person will be took 30 seconds, then 300 households will be took 150 minutes. Each community worker will spend 300 minutes on collecting data. If anyone forgets to report their data,they need to call them. In the majority situations, the massive contents of chatting are useless for other group members, which might be an information explosion for the rest of members. The reason why they do not adopt an online health survey is that residents have different digital skills which will lead to many problems in practices.

3.3.5 Attitudes on sharing sensitive data

When asking about participants whether they would like to provide their health data, travel history and close contact, most of interviewees from China expressed that they would like to share their data if it is useful for further preventing and controlling coronavirus. This because, in China, if new cases were identified, the way to track close contracts of confirmed cases are based on face-to-face interviews. According to checking digital payment history and inquiry, the completeness travel history has been collected and published among public to give an alert for people who have been their before. Therefore, participants in China had high acceptance for sharing their data.

Moreover, some participants from China expressed that they do not use mobile phone quite often and there are less information saved locally, so they do not really care about their data. By comparison, participants from the Netherlands have more cautious attitudes on providing their personal data. And one of the most concerns is who is collecting data. This is the same as in the context of the China. If an authoritative hospital takes responsibility of data , they would like to contribute their personal information.

3.3.6 Key Proposed Features of mHealth-based Applications

According to the result of current concerns, we had a general knowledge about community members-based mHealth tools for coronavirus. In this section, the app features were generated by group discussion of three participants to represent family members in China at first. Then, the interviewer expressed the proposed key features in the context of China to Dutch health experts and asked their opinions about what do you think about this

potential solutions, whether this will be helpful for current work flows, and are there any suggestions or advice.

3.3.6.1 Syndromic record

Firstly, family members had a highly interest on syndromic record. This because that senior citizens are often forgetful and it is difficult to keep a careful eye on their parents' health conditions everyday, since their parents lives alone. Sometimes, they accompany their parents to hospital and they could not answer doctor's questions related to symptoms exactly. Therefore, recording symptoms with severity level and duration could help for providing a careful history and follow-up.

3.3.6.2 Social supporting

Correspondingly, a feature that allows senior citizens to sharing and interact with people having close relationships. Sharing record of symptoms was proposed by participants. It is quite convenient for them to learn about and monitor health condition of senior citizen. And this also help to timely decision making.

3.3.6.3 Exporting data

Only recording symptoms could not facilitate senior citizens to behavioral and regular use. However, exporting data to health workers could be considered as a key feature for improving motivation of adoption of the system. During the interviews, it was much clear that participants from China were interested in having a system that could interact with health workers when symptoms occur. This could be done by involving the role of health workers in the system.
One of participants in the Netherlands, a doctor working at clinic, provided a positive answer about having syndromic tracking system, and said that "measuring patients at home and then send results to doctor by an mobile application would very helpful, especially when we could not see the patients".

3.3.6.4 Reminders

Meanwhile, besides pushing notification for reporting data, participants also hoped that the system could reminder for personal hygiene practices. For example, to avoid infection, notifying senior citizens for carefully washing hands, drinking water and indoor ventilation could be effective and key approaches.

3.3.6.5 Information provision

Instead of history contract tracking, participants recommended the feature that offer accuracy information about high risk areas to alert senior citizens. It would be an important warning role for prevention senior citizens to access to high risk areas.

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4

Requirement Generation

After various methods of needs assessment conducted with senior citizens and health workers, there were a number of clear ideal features collected to define a conceptual solution and subsequently the main requirements have been determined. To gain an in-depth understanding about requirements on technical details, we transferred unstructured needs to concrete requirements.

4.1 Actors and Goals

Participatory-based self-reporting system not only includes community members as an only role of actor, but also considers the engagement of community and health workers. By doing so, the proposed ideas could be fully adapted into local environment.The Table4.1 shown below provided an overview of actors and goals. The senior citizens would like to have a mHealth-based tool for managing their symptoms. This could help community and health workers to reduce their workload and change patients' seeking behavior.Moreover, other family members had a high concerns on learn about health conditions of senior citizens through an application.

4.2 Use Case Scenarios

Based on the needs identified, the key idea began when some health and community workers complained about the difficulty of collecting data and follow up from elderly people during the epidemic in the context of China. There is a highly demand on finding out whether it would be possible to design and develop a solution that could make data collection from senior citizens easier.

Actors	Goals
Senior citizens	To record the symptoms
	To access to community and health workers
	To get information about high risk areas of coronavirus
Community and health workers	To measure patients at home
	To reduce dependence on doctors
	To get an overview of patients' symptoms
Young family members	To support senior citizens with symptoms to get timely guidelines or treatments
	Learn about senior citizens‘ health conditions

Table 4.1: Actors and goals

The Figure 4.1 shows how different actors can make use of the application to health data collection and reporting. There were two types of arrow which represents different use cases. The process of application followed by arrows with solid line, from step 1 to step 4, has been identified in China and the Netherlands. However, due to the difference measures and attitudes on prevention and control COVID-19, there was a proposed use case that could be useful in the context of China.

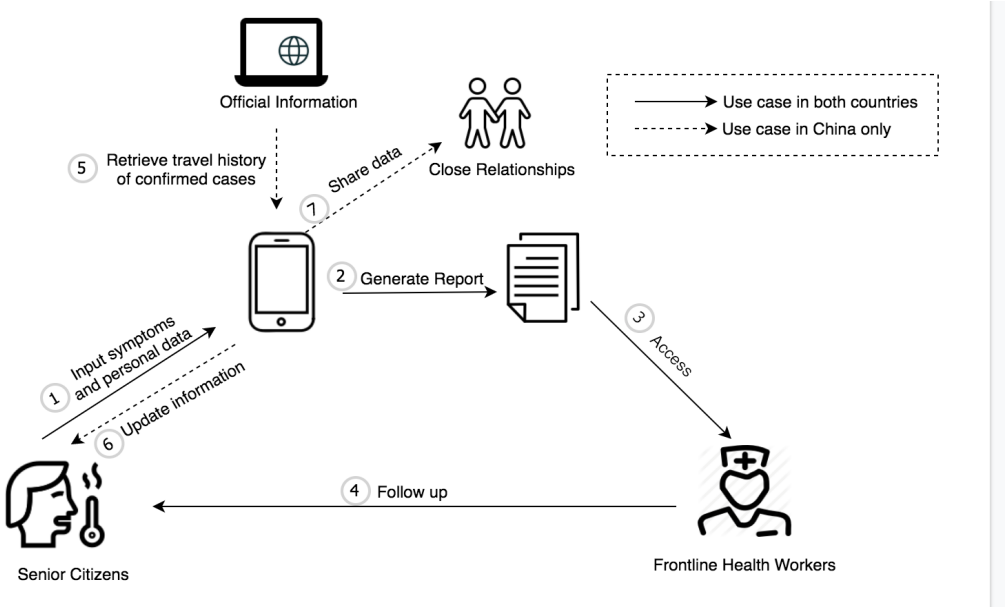


Figure 4.1: The process of the system

Firstly, senior citizens who have occurred symptoms as similar as coronavirus could record

their health conditions by the application. Then the data are stored in the database of application and could be used and accessed by health workers. And it also could be shared to people with close relationship. Once the report has been sent, health workers could have a quick and simple screening based on the data provided to make a further follow up, such as voice call and face to face interview. Something that scares most of senior citizens with suspect symptoms is infection in the emergency department of coronavirus if the application could allow general practitioners and community workers to rapidly and simple screening with this would be an enormous reassurance.
Besides health data collection and reporting, the use case of prevention infection based on travel history information has been proposed in the context of China. Through collecting travel history data from official website, the application could present information of the high risk areas to users to give an alter. Although this could help to prevent senior citizens to avoid high risk areas, the use case needs governmental authorities to carry out a large number of epidemiological surveys and willing to publish information for public, which is less feasible in the context of the Netherlands.

4.3 Key Requirements

There were several requirements related to system and environment identified in both two countries based on the process of needs analysis and use case elaboration.
In this section, a couple of key requirements that system must, should and could have, divided into functional requirements 4.2 and non-functional requirements, are identified through the process of needs analysis and use case elaboration.

4.3.1 Functional Requirements

The list of functional requirements has been drawn up. It is important to note that functional requirements from FR1 to FR5 in the below Table 4.2 are related to the step 1 to step 4 in the Figure 4.1. The FR6 and FR7 are refers to the step 5 to 6.

4.3.2 Non-functional Requirements

According to the results of functional requirements, a list of non-functional requirements and corresponding rationale has been introduced. It is important and necessary to implement the system as well as fulfill these non functional requirements.
C1-Use friendliness: To facilitate and encourage the adoption of applications among senior citizens, the system, including user interface, navigation and data input methods,

Requirements	definition
FR1-login and registration	The system must be only used after login. And people who are the first time to use the system must to register as an user.
FR2-Identify symptoms	The user should be able to input the symptoms he/she had and their personal data, and the system also have to identify the severity of the symptom.
FR3-Push notifications	The system should remind users of reporting their data in a continual period after their first reporting.
FR4-Protect data	The personal information and health status provided by users must be stored in a protect way.
FR5-Report data	Once health workers access to the data, the report must be generated.
FR6-Retrieve data	The system could be able to automatically retrieve travel history data of confirmed cases from the official website.
FR7-Update information	The system could be able to update information of high risk areas.

Table 4.2: Functional Requirements

must keep the level of complexity as low as possible. Especially in China, low education level and illiteracy among senior citizens have been a barrier for using and accepting mobile applications. Without help, senior citizens are used to be hardly to individually use a large number of popular mobile applications.

C2-Fast user actions: It is important that reducing time on user actions could contribute to improving usability. It is difficult for senior citizens to maintain their attention the whole time, when performing tasks or answering a long health questionnaires. The speed of user actions could be improved by limited reading and operation steps.

C3-Understandability: To avoid subjective assumptions and user errors, the application must have a very clear, explicit and detailed health condition assessment standard. It is very important for end users to report accuracy health data. Standardised report could be generated for health workers to further decision making.

C4-Confidentiality: The system must be able to protect sensitive data against unauthorized access and modification. To be specific, in addition to users actively sharing their data to others, all the data collected from users should only be authorized accessed by local GPs or health workers.

C5-Low cost: The system should not have external or internal cost from the adoption to

implement.

C6-Technology choice: The application should be based on the most convenient platform or technology. This can be explained that the application should fit for various devices, which could be widely used. Moreover, in China, convenience is referred to easy to download and installation. This because that it is difficult to publicity with installation of mobile application, which will meet problems downloading application due to common poor digital skills among senior citizens, according to the interview with front-line health workers from China.

4.3.3 Environment related Requirements

In order to design a successful participatory-based application, the following requirements must to be met, which could help for facilitating user motivation.

4.3.3.1 Comply with local privacy law

Although there were different laws and attentions on privacy protection between two countries, the system collects sensitive data, including personal data such as name and telephone numbers and health data, which must comply with local privacy law. In particular, the General Data Protection Regulation (GDPR), and China's Cyber security Law and the Personal Information Security Specification applies for protecting privacy of EU and Chinese citizens separately.

Taking Health QR code as an example, when asking the feasible of participatory tracking coronavirus systems, all the interviewees in the Netherlands gave the same answer that it is very difficult to work in the Netherlands, due to the strict privacy rule. This will makes tracking system become to a complicated challenge. Therefore, it is important to comply with local privacy law, which facilitates the feasible of mHealth tools.

China has relatively loosely policy on personal data used in mobile application compared to the Netherlands. At the initial stage of coronavirus surveillance, community workers used voice call to do data collection. However with the outbreak, voice call was no longer efficiency for community workers. Then, group chatting through WeChat has been widely adopted for collecting health data from people who has been exposed under coronavirus. According to conversation with a community workers, she used to require all the members in chatting group to change their username to real name as well as house number, which allows she can identify people easily. Such sensitive data including health data and

personal data has to be exposed among groups members. There is a high possibility of internet fraud due to privacy leak.

4.3.3.2 High transparency

There is a high concerns on personal data in the Netherlands. Before using a such application, it is necessary to explain about what kinds of data will be collected, where the data will be recorded, who have a right access to the data, and how to deal with unused data. When asking the interviewees from China about health QR code related knowledge, most of them could not answer about what kind of data are collected, who takes responsibility for managing data and how long data will be stored. Chinese media reports also noted that there were only 3 places that have informed consent and privacy protection provisions among 14 provinces and cities (34). In order to clear understand how the health QR code works in Changchun, the researcher sought an answer from official staff working at local government service and digital construction administration though hot-line. But it's still unclear how exactly the app works. This leads to a reasonable imagination about how massive information collected will be used and addressed after epidemic. It can be seen that lack of transparent is common in a national level.

4.3.3.3 Forge a stronger collaboration

The effective collaboration between local hospitals and the system is crucial and necessary for improving motivations and trust of envisaged users and promotion of the practise. Firstly it is common about low motivation among community members. Community workers expressed that there were much effort the government paid to promote and implement health QR code among public in China. And all the mHealth-based approaches for community members are based on governmental interference in China. If there is no compulsory rule for the adoption of relevant tools, the way of collaboration with local hospitals to increase interest in such mHealth tools would be significantly important. Moreover, in the context of China, governmental authorities also can be regarded as a strong partnership.

4.4 Design Options

There were several design questions has been generated before the development and need to be answered. In order to provide accuracy answers, multiple methods has been applied for decision making, which includes participatory design, observation and Questions, Options and Criteria (QOC) analysis technique (35).

4.4.1 Technology choice

There are various types of software application that could be chose for developing the system, normally, including three types, which are web-application, native mobile application and hybrid application.

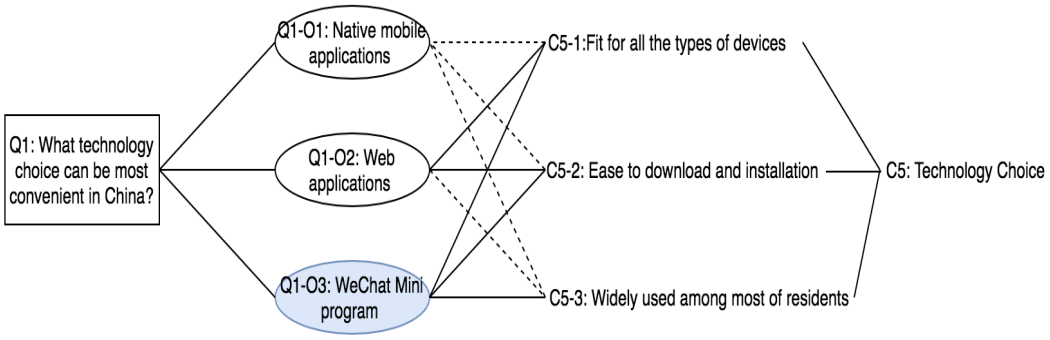


Figure 4.2: QOC1: Technology choice in China

But recently, there is a novel and popular form of software applications in China, called mini program. Mini program is an app integration within an application (36). WeChat mini program has been considered as a possible solution for the system. The reasons choosing WeChat as a platform because it is one of the most popular application in China. Compared to the traditional types of software application, the mini program is much more suitable for the system in the context of China. The rationale is shown in the Figure 4.2. As similar as web applications, mini programs do not need to download and installation from application stores, compared to Native mobile applications. But WeChat mini program could be widely used among public in China as mentioned before. (cite).

4.4.2 Input Data Methods

The input data methods include various ways to collect data from senior citizens. However due to poor digital skill and low literacy in China, selecting most suitable input data methods is very important. Traditionally, paper-based health condition assessment can be answered by option list, open questions, and closed questions. Visual rating scale is a common date entry method for understanding the severity of the symptom. The rationales for option list and visual rating scale are described in the below Figure 4.3.

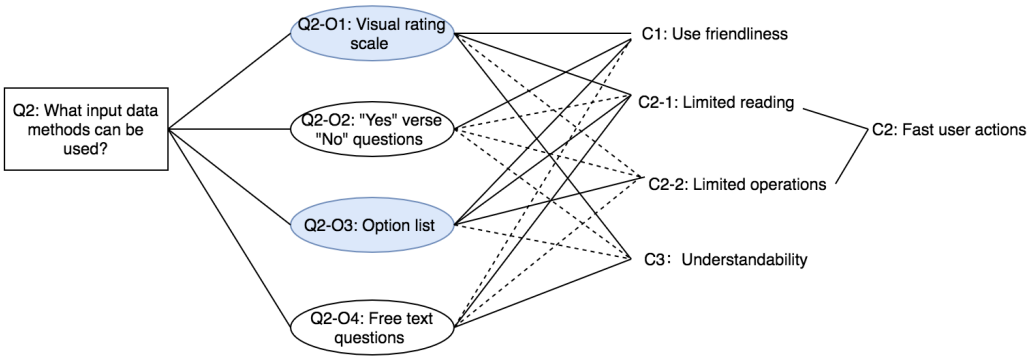


Figure 4.3: QOC2 Input Data Methods

4.4.3 Data Collection Methods

Active reporting refers that user has unawareness to input data. In the passive mode, an advanced feature of the mobile device or wearable devices could record data without users involvement. In this case, wearable device has been considered as an alternative choice. However, adopting wearable devices to self-report is less feasible in the system due to high cost, high possibility of personal data leakage and poor user friendliness.

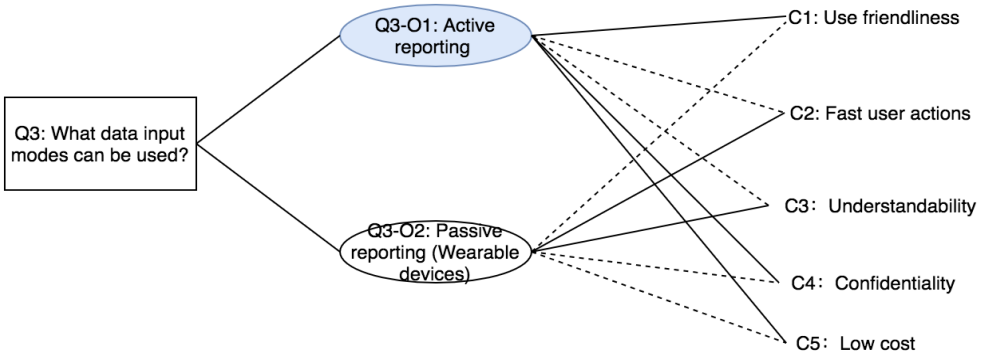


Figure 4.4: QOC3: Data Collection Methods

4.4.4 Information Provision Methods

The information of high risk areas can be presented for user by the forms of text or visual map. Visual map has less requirements on literacy and it is easy to understand. However, this requires frequent map updates, which highly dependents on internet connection and speed.

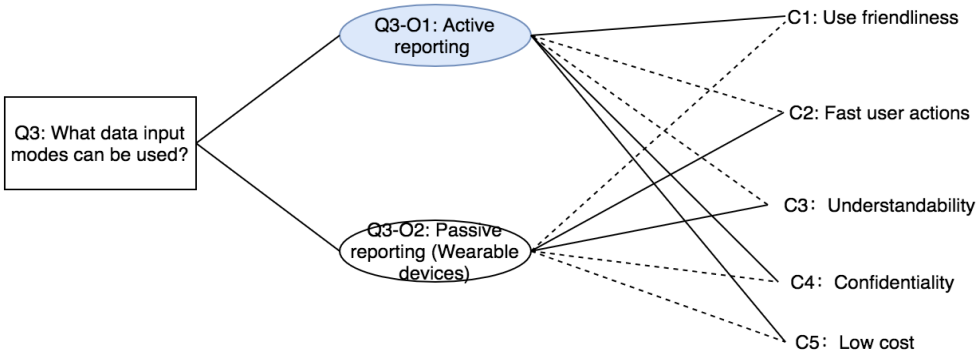


Figure 4.5: QOC4: Information provision Methods

5

Low-fidelity Prototype

The concern about how to get accuracy health data from senior citizens is always fundamental and important for designing a successful participatory syndromic surveillance. There is a highly demand on finding out whether it would be possible to design an user interface as simple as much possible that could encourage senior citizens to submit accuracy data. For instance, the ability of message typing and filling text-based online forms are common low for senior citizens. Even voice call could be ignored due to a sharp hearing. This viewpoint has also been put forward by the health worker. Senior citizens will feel confused and afraid of error operation if using an complex mobile application. This has an negative influence on their confidence for adoption of mobile application.
Therefore, how to simplify is the key problem. To solve this problem, an in-depth understanding about the level of complexity on operating application and co-design with senior citizens are significant crucial and necessary.

5.1 Observation of exists applications

According to the results of survey, the major problems encountered by aged people are the complexity of user interface (45%) and misunderstanding of icons, symbols and implication (38%). However, when asked about whether they are willing to give a help, 43% participants expressed that their older family members often forget about the content taught.
To explore the details that people meet when using mobile applications and health QR codes in fact, 6 participants in 50s, 60s and 70s from China were asked to perform different tasks shown in the below Table 5.1. All of participants have experience on using a smart phone. However, when they were asked for presenting their health QR codes to security

personnel, most of the elderly need to ask a help from security personnel or people next to them.

Mobile application	Task	Behaviors	Questions Description
Google Store/ Apple Store	Installing an application in their mobile phone	Click the icon of google store/ apple store- input the name of application- identify the match one-click “download”	Participants cannot identify the application store; have a problem with texting including misspelling; click the icon of “download” several times, which makes them unknown whether it is download or not;
Mini program: Health QR codes within WeChat	Presenting their health QR codes	Click icon of WeChat-click the search box-input the name of mini program – click the icon of mini program — click the icon of “health QR code”	Participants do not know where the search box is; and cannot find the correct mini program, when accessing to mini program, the user interface is too complex, and they cannot identify which button should be clicked.
Mini program: Health QR codes within WeChat	Screening the QR codes to show their health QR codes	Click icon of WeChat-click the icon of "+"-select “screening” function- screening QR codes	The icon of plus is too small and without any word explanations. It is easy to click the wrong one. Sometimes, participants could not well align with the target QR codes.
Digitized health questionnaire	Filling in the digitized health questionnaire	Click the link of health questionnaires-answering the questions- submitting the answers	Opening the link take some times which makes confused. Too much and small texts and information. It is easy to miss some of questions. This leads to the error of submitting.

Table 5.1: Problems encountered by participants in using mobile applications

During the observation, two participants in late 50s could perform the middle two tasks individually without any helps but they spent much time on answering health questionnaires and downloading application from application stores. They had less or even no experience about downloading applications. Especially for participant using apple store, the password and username were asked to provide, which they did not not know. Interviewees above 50 said even they knew how to download, first registration was very difficult for

them. The applications they had in mobile were installed by their younger family members. For participants in their 70s, we tough them how to find and show their health QR. After step by step demonstrating twice, the oldest participant had finally learned. The another participant in 70s still could not cope with that individual. This because the participant with limited literacy cannot understand symbols and letters, such as "+", "screening" in Chinese. Moreover, the oldest participant asked a help for deleting a conversation in his WeChat. Because he cannot find the delete function and there were texts which is unreadable.

5.2 Co-design Low-fidelity Prototype

With the basic understanding of the level of complexity, the design of low-fidelity prototype has been proposed with the same three participants in the Section 3.3.6.
Based on the results of observation, the login and registration procedure has been modified by following Figure 5.1. Normally, the various methods to register as an users by using telephone, email and social media have been widely used, shown in the Figure 5.1 (a). However, to limit texting, only remaining using WeChat account to login and registration, shown in the Figure 5.1 (b), and then redirecting users automatically to authorization interface shown in the Figure 5.1 (c). Once the user clicks the button, the mini-program could be used.

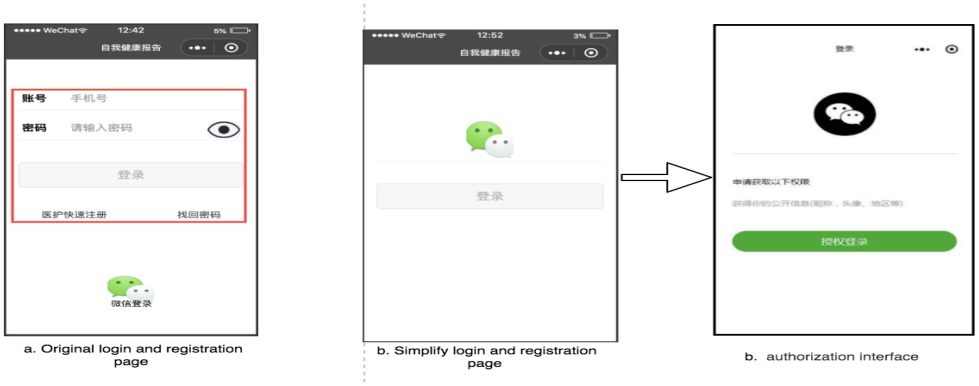


Figure 5.1: Simplify login and registration page

The Figure 5.2 has been proposed with participants. The main ideas came up by participants were that each option in the user interface must have its own icon and each task must be completed as less steps as possible. At the home page, there were four options with its own icons, namely personal information, reporting, alerting, and notification, shown in

the Figure 5.2 (a). Follow by, if an user select "reporting" icon, the health questionnaire page will be redirected. The option lists are provided and if a specific symptom is selected, the following question is to identify severity level by using predefined visual rating scale, shown in the Figure 5.2 (c). When the submit button is clicked, the page will show the icon of success submitting.

If a user clicks alerting icon, the visual map will be shown in the interface. Within the map, user is allowed to identify high risk areas by checking his own current location and the circle of warning areas, shown in the Figure 5.2 (e). Moreover, the notification can be personalized set through selecting prefer certain time, alerting items.

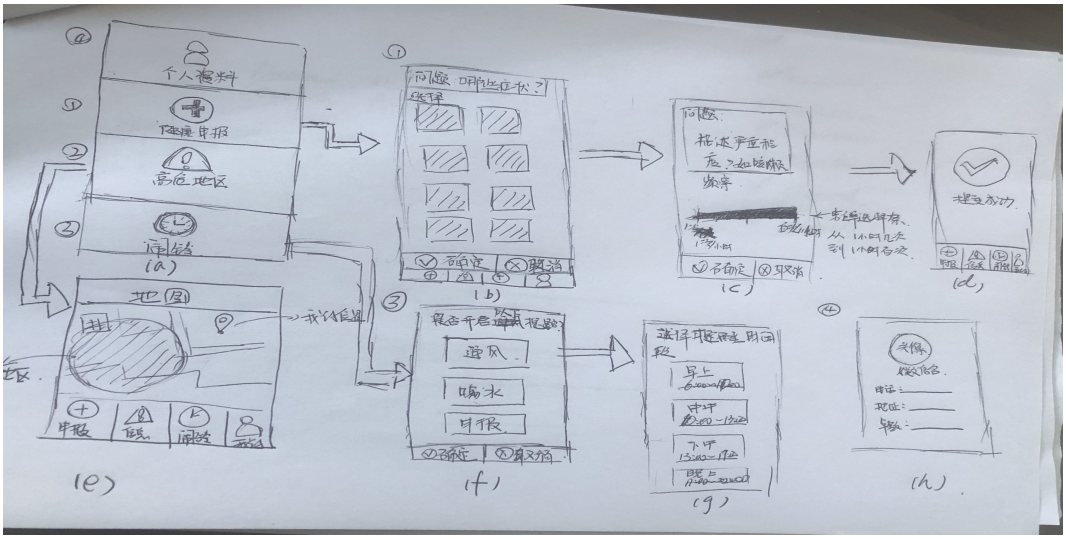


Figure 5.2: Co-design Low-fidelity Prototype

6

Comparison

The differences and similarities between from China and the Netherlands among previous sections has already been introduced. Therefore, in this section, the summary of comparison is provided.

Although national conditions and scenarios for coronavirus between China and the Netherlands are completely different, there were still few similarities identified. Firstly, it is hard to promotion of the participatory-based mHealth applications for community members due to low motivation on mHealth intervention. Surveillance based on public engagement has implemented in both countries. However, participatory diseases surveillance has involved governmental interference in china. To some extent, residences in China were required to self-reporting their data. As for the Netherlands, such participatory-based data collection is only useful for gaining an in-depth understanding of coronavirus within the country. Despite there were several mHealth approaches proposed and used for participatory surveillance, it is important to note that real needs from local people about mHealth approaches for such system are crucial but missing. This might lead to low adoption of mHealth tools. However, another reason causing low adoption might be lack of stronger partnership with hospital. This can be seen that there is a high expectation on exporting data to health workers that has been expressed, despite the purposes of implementing this feature were different. Moreover, although Bluetooth-based tracking has positive influence on prevention and control the outbreak, there was a common less technology acceptance in both countries. The reason has been discussed in the previous section.

One of biggest differences between two countries is privacy protection either from the perspective of policy or privacy. Compared to China, the Netherlands has a more perfect law on protecting personal data. This leads to a situation that some key and successful prevention measure in China cannot be applied in the Netherlands, as well as awareness on

data protecting from the perspective of local people. Citizens in China commonly have less concerns on data leakage when using a mobile application, which is significantly different with Dutch citizens. Due to the loose privacy law and less concerns on data protection, it was quite common that transparency of data is relatively low.
Moreover, the feature of information provision could not be implemented in the Netherlands. The reasons behinds that are complex. It could be caused by combined effects, such as low motivation on coronavirus in combined with privacy protection.

Categories	**Items**	**China**	**Netherlands**
User	Concerns on coronavirus diseases	More	Less
	Attitudes on self-protection	Positive	Negative
	Motivation on mHealth tools	Low	Low
	Major method used for self protection	Voluntary limiting movement	Social distancing
System	Bluetooth-based tracking	Won't have	Won't have
	Syndromic record	Must have	Should have
	Push notification	Must have	Could have
	Export data	Must have	Must have
	Social supporting	Could have	Could have
	Information provision	Should have	Could have
Environment	Privacy protection Low	Loose	Tight
	High transparency	Low	High
	Forge a stronger collaboration	Governmental authorities and hospital	Hospital
	Simplicity	High concerns	Low concerns

Table 6.1: Summary of comparison

7

Discussions

The aim of the research is to investigate the potential solution on participatory-based mHealth tools for strengthening the surveillance data in China and the Netherlands. This chapter provided the limitations and further work.

7.1 Limitation

The research has been conducted during the outbreak of coronavirus. And we unavoidably encountered some limitations caused by this special period.

One of major limitations is the limited numbers of participants. At the beginning of the research, from March to May, both China and the Netherlands made effort on control infection by applying different extents on travel restriction. Online interview has becoming a major way to collect data. However, due to a common low digital skill among senior citizens in China, the data collected by voice call and video call is not satisfactory. Therefore, senior citizens who can be accepted offline interview have been chose. However, it limits the number of senior citizens to join in. Moreover, the same reason applying on the limited number of health workers as participants. Health workers working on combating coronavirus were busy and hard to be accessed due to special working environment. But in the end, three health experts from the Netherlands and three community workers and health workers from China were invited to share their knowledge.

Another limitation is less interview recording and photographic evidence. To proof data authenticity of interview, providing evidences can be considered as a main way. The requests of recording or photo have been rejected in China. The reasons behind are complex. Participants from China were afraid of being identified and hard to express the really thoughts

if the conversation was recorded. As for community workers working at the governmental authorities, there is a strict rule for the forms of recording interviews. Moreover, the conversations among Chinese participants have been conducted by their native language. However, to maximum proofing data authenticity, the personal contact address and name were recorded and this could be checked by the supervisor.

Furthermore, due to time constrains, the proposed solution so far has only focusing on the conceptual level. At the beginning stage of research, the initial research direction focused on dengue in Malaysia and the plan to conduct a field trip to Malaysia was scheduled on the late of February. Due to the outbreak of coronavirus disease in Asia and willingness of collaborating university in Malaysia, the field trip has been cancelled. Sequentially, the field trip in Ghana as an alternative has been proposed in the middle of March. However, with the spread of coronavirus around world, the travel restriction has been introduced by the government and the field trip has been cancelled again. Due to less concerns and experience on dengue either in China and the Netherlands, the research direction had to be revised again and coronavirus as a target disease.

Uncontrollable situations of coronavirus in China and the Netherlands lead that the results of context analysis and needs have timeliness. The local context related to coronavirus could be totally difference within few months. And the user needs are easily changed accordingly.

7.2 Future Work

The solution of designing a self-reporting mHealth-base tool for participatory surveillance systems have been already identified. The differences and similarities between China and the Netherlands also can be found.

The most expectation for the future is to turn the solution into a true mHealth application, which could be really tested among real users. In this way, researchers are allowed to explore and investigate more feedback and details about needs and differences between two countries. Once the data collected by real users, medical researchers and experts could have a in-depth and detailed understanding about coronavirus disease.

Moreover, the solution could be regarded as a great inspiration for any researches or projects of mHealth tools. This could be further extended to apply for different groups of community members, instead of only considering senior citizens. Furthermore, the proposed solution could be applied among different countries to explore and identify common successful factors of designing a participatory-based mHealth application.

Moreover, although there are low interests and acceptance on the functionality of travel history tracking in China and the Netherlands, it is still an effective way to detect infection in an early stage, which could be more useful in the countries with outbreak. Therefore, there could be efforts on exploring how to track potential infection cases in high risk areas and what kinds of advanced technologies can be used for precise tracking.

8

Conclusion

The research illustrates how can mHealth technologies efficiently support self-reporting for peoplewith higher concerns of COVID-19, with observations from China and Netherlands, and how different across countries. The research using ICT4D 3.0 framework as an outline to explore the local context, user needs and requirements in those two countries. As for the answer about how are people with higher concerns of COVID-19 currently doing for reporting their health status, the major way that has been conducted to collect health data was active detection in China and passive detection in the Netherlands.

Key features has been proposed by envisaged users and validated by health workers. The features of syndromic record, exporting data, reminders and social supporting has been common agreed. As for the feature of information provision, because it might require to publish personal data on public even under anonymous, there is low feasibility and technology acceptance in the Netherlands.

Moreover, the ways to encourage users to submit accuracy data has been divided into two aspect: (I) from the internal viewpoint: to improve user interface design; user behavior can be improved by design an ease to understand user interface. (II) from the external view point: to fulfill environment related requirements; This is helpful to improve the trust of user when adopting the application.

9

Appendix

9.1 Figure description for Current Approaches in China

9.2 Interview portfolio

The list below has provided description of interviewees, including two community workers and one health workers from China and three health workers from the Netherlands.
From the perspective of health workers in China:

- A work personnel from Law enforcement team of Agricultural Committee in Changchun city who is taking responsibility for contacting, detecting and monitoring people who have may been exposed to an infectious agent or diseases.
- A Community worker from Heping Community in Changchun City, who is taking charge of collecting data from general public and reporting data to related authorities.
- A health worker from Jinzhou Central Hospital, who has been working more than two and half years.

From the perspective of health workers in the Netherlands:

- A medical doctor graduated from 2013 and has one of half year working experience and after that she had an education to become a general practitioner. And next September she will be a GP two years.
- A general practitioner from 2017 and also teaching at Vrije Universiteit about general practitioner training not only about medical problem but also communication since last year. He had an experience on first-aid medicine and regular training, and rich

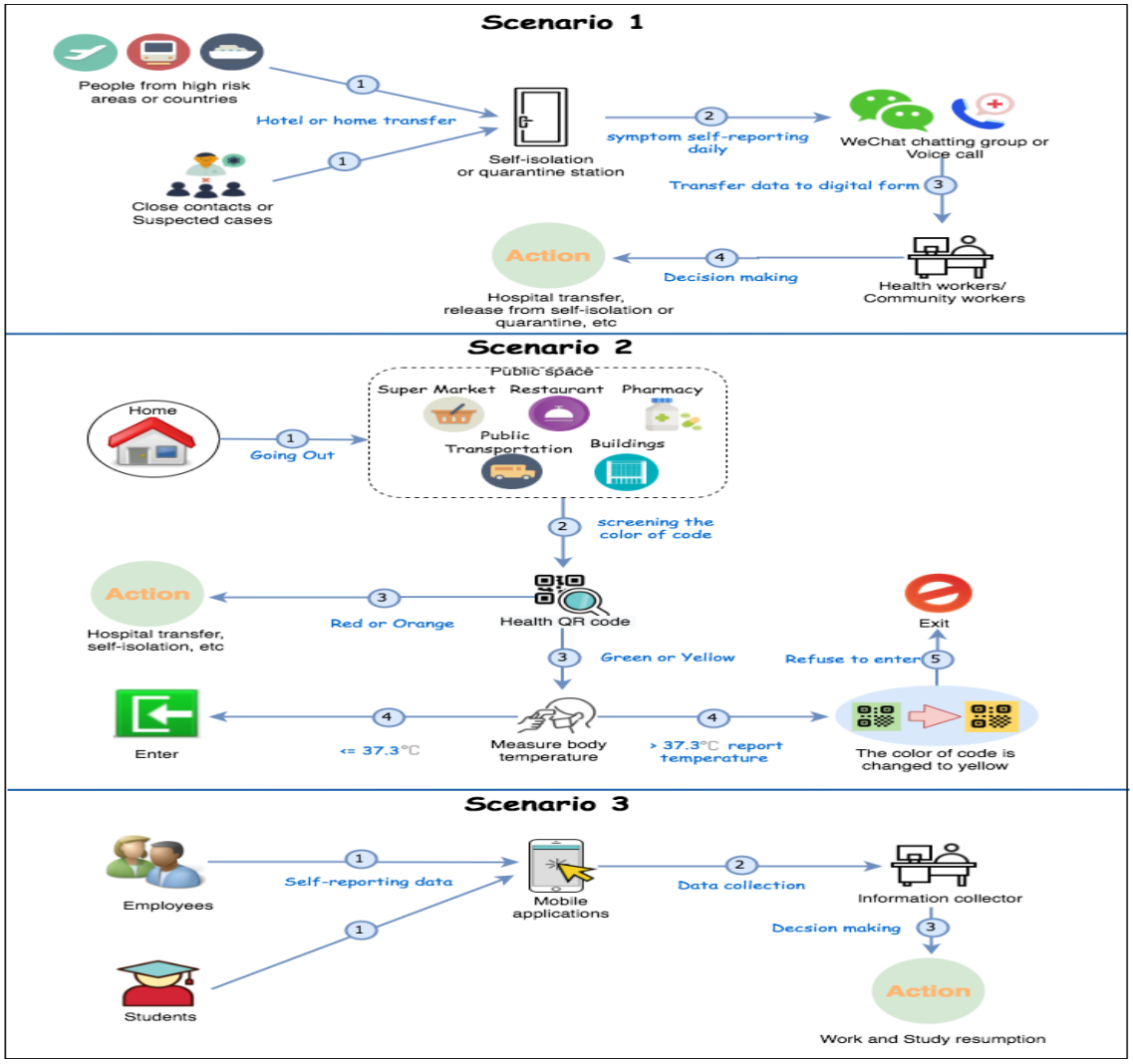


Figure 9.1: Three scenarios using mHealth technologies in China

knowledge on surgery and psychiatry. The main responsibility is the first line to get access to health care, but sometime also refer to second lines

– A residence of internal medicine and currently is working on clinic. For coronavirus field, she is mostly working on it.

Interview Portfolio（English）

1. **Context Analysis and Need Assessment (20 mins)**:

Health experts OR relevant experts:

- To what extent the role of voluntary surveillance system is played to detect and monitor COVID-19 in your country?
- Do you think this is a better approach to enable health authorities to control and combat the outbreak than a Bluetooth-based approach?
- *Do you think it is feasible for adopting a mobile application that allow people self-report their information?*

For all interviews:

- Would you be happy to provide your personal data including health condition, geographical location and contacts to surveillance system?
- Would you like participate in a routine self-reporting system on a continuous basis if you were exposed to an infectious agent or diseases or had very mild symptoms?
- Do you experience problems with answering health status questionnaires? (for example, is my idea of a continuous, unproductive dry cough the same as health practitioner's?)

Interview Portfolio（Chinese）

- **医学方面或有关部门的专家:**

- 参与性的疾病监测系统在检测和检测新冠肺炎方面扮演了什么样的角色在你的国家？
- 你认为，相比于蓝牙方式，这种参与性的方式可以更好的控制和减轻新冠肺炎的爆发么？

所有受访者：

- 你会提供自己私人的信息到监测系统么（包括健康状况，地理位置和联系人）？
- 假设你有了轻微的症状或者你曾经暴露在存在病毒的环境中，你愿意参加持续参加这样一个日常自我报告的系统么？
- 当你被回答一些关于健康状态的问卷时，你遇到过困难么？（比如，我认为的持续干咳和医生认为的是不是一样？）

9.3 Survey

The questionnaires include two parts: one is about attitudes on self-reporting behavior; the other is about problems when using mobile applications. The questionnaires were distributed on WeChat, a social platform, and 53 participants provided their answers and ideas.

9.3.1 Survey questions

Regarding the use of mobile phones by middle-aged and elderly people, their feelings and suggestions on mobile phone-based health declarations during the epidemic

During the epidemic, people used mobile phone tracking, health codes and other software to provide private information to fight the epidemic. However, this method caused certain difficulties in the lives of middle-aged and elderly people with low digital literacy. Therefore, this survey mainly focuses on the problems encountered by middle-aged and elderly people when using mobile phones and during the fight against the epidemic.

1

1 Do you currently have middle-aged and elderly people in your family?

- ○ Have
- ○ No

2 What is the age of the elders in your family

- ○ 51-60 years old
- ○ 61-70 years old
- ○ 71-80 years old
- ○ Over 80 years old

3 The academic qualifications of the elders in your family

- ○ Junior high school and below
- ○ High school / vocational high school / technical school / technical secondary school
- ○ Junior college
- ○ Undergraduate
- ○ Postgraduate

4 The daily residence of the elders in your family

- ○ Municipalities and provincial capitals
- ○ Prefecture-level cities (including sub-provincial cities)
- ○ County (county city level)
- ○ Township Village

5 Do elders in your family own a mobile phone?

- ○ Smart touch screen mobile phone that can download all kinds of software
- ○ Key phone with only basic call and message function
- ○ no mobile phone

6 What is the main purpose of the elders in your family using mobile phones?

- ☐ instant messaging
- ☐ Leisure and entertainment
- ☐ online shopping
- ☐ online news
- ☐ Online health
- ☐ other

7 Do they usually come to you when they encounter problems with the use of mobile phone software?

- ☐ Often
- ☐ sometimes
- ☐ Basically not

8 Do you think teaching middle-aged and elderly people to use mobile phones or mobile phone software is a waste of time?

- ○ Yes, because the church forgets the next time
- ○ No, I would be happy to teach them how to use

9 What is the most common problem encountered by the elders in your family when using mobile phone applications?

- [ ] I don't know how to download mobile apps from Yingyou Mall
- [ ] The registration process is more complicated
- [ ] The application interface is too complicated, there are too many choices, and I don't know how to operate
- [ ] Do not understand the symbols, graphics or prompts in the operation interface
- [ ] Can't see text and graphics
- [ ] Inaudible voice or prompts can't be heard clearly
- [ ] Can't remember the operation flow when completing a long procedure
- [ ] High-tech products are too difficult to learn
- [ ] other

10 What characteristics do you think middle-aged and elderly people need to have when using mobile apps?

- [ ] Simplified user interface
- [ ] The functions presented on the interface are more intuitive and reduce metaphors
- [ ] Reduce text input
- [ ] Login method using face, gesture or voice
- [ ] Reduce options
- [ ] other

11 Regarding the fight against the new type of pneumonia, what is the degree of concern in your family?

- ○ Very concerned
- ○ attention
- ○ general
- ○ Not too concerned
- ○ Not concerned

12 What are their main channels for understanding and mastering information on the new pneumonia epidemic?

- [ ] newspaper
- [ ] Weibo
- [ ] Circle of friends
- [ ] TV
- [ ] Local forum
- [ ] WeChat group
- [ ] Official account push message
- [ ] Website and news app
- [ ] Relatives and friends
- [ ] other

13 What are their comments on the response measures of daily inquiries about health status?

- ( ) Very necessary
- ( ) More necessary
- ( ) general
- ( ) Not necessary
- ( ) unnecessary

14 What kind of comments do the elders in your family have on the response measures of health codes?

- [ ] Effective and timely control of the spread of the epidemic
- [ ] Inconvenience in life to a certain extent
- [ ] Not necessary at all, the form is greater than the content
- [ ] Worry about personal privacy
- [ ] Not sure about the specific reason for use

15 Are they willing to provide their private data for use in the fight against new coronary pneumonia?

- [ ] Willing to provide physical health data
- [ ] Willing to provide whereabouts
- [ ] Willing to provide a list of close contacts and contact information
- [ ] Not willing

16 Do the elders in your family prefer to share their private data with real names or anonymously?

- [ ] Real name
- [ ] anonymous

Chinese version

关于中老年人对手机使用情况，和疫情期间基于手机的健康申报的感受和建议

疫情期间，人们基于手机的轨迹追踪，健康码等软件提供私人信息对抗疫情，然而这种方式对相对于低数字素质的中老年人的生活造成了一定困难。因此，本次调查主要针对中老人在使用手机时和抗疫期间所遇到问题。

1、您家中目前有中老年人么？ (单选题 *必答)

- ○ 有
- ○ 没有

2、您家中长辈的年龄是 (单选题 *必答)

- ○ 51-60 岁
- ○ 61-70 岁
- ○ 71-80 岁
- ○ 80 岁以上

3、您家中长辈的学历 (单选题 *必答)

- ○ 初中及以下
- ○ 高中/职高/技校/中专
- ○ 大专

○ 本科
○ 硕博研究生

4、您家中长辈的日常居住地 (单选题 *必答)

○ 直辖市、省会城市
○ 地级市（含副省级城市）
○ 县（县市级）
○ 乡镇村

5、您家中长辈是否拥有手机？ (单选题 *必答)

○ 可以下载各类软件的智能触摸屏手机
○ 只有基本通话发信息功能的按键手机
○ 没有手机

6、您家中长辈使用手机最主要的目的是？ (多选题 *必答)

☐ 即时通信
☐ 休闲娱乐
☐ 网络购物
☐ 网络新闻
☐ 网上健康
☐ 其他

7、平时他们遇到手机软件的使用问题会来问你么？ (多选题 *必答)

☐ 经常会
☐ 偶尔会
☐ 基本不会

8、您是否觉得教中老人使用手机或手机软件比较浪费时间？ (单选题 *必答)

○ 是的，因为教会一次下一次就忘了
○ 不是，我很乐意教他们如何使用

9、您家中长辈使用手机应用软件时最常遇到的问题是？ (多选题 *必答)

☐ 不知道如何从应有商城下载手机应用
☐ 注册过程比较复杂
☐ 应用界面过于复杂，选择太多，不知道如何操作
☐ 不明白操作界面中的符号，图形或提示
☐ 看不清文字，图形
☐ 听不清语音或提示听不清楚
☐ 当完成一项程序较长时，记不住操作流程
☐ 高科技产品学习起来太困难

☐ 其他 _____

10、您觉得中老年人使用手机应用时需要具有哪些特点？ (多选题 *必答)

☐ 用户界面简单化
☐ 界面呈现的功能更加直观，减少隐喻
☐ 减少文字输入
☐ 登录方式使用面部，手势或语音方式
☐ 减少选择项
☐ 其他 _____

11、关于抗击新型肺炎疫情，您家中长辈的关注程度如何？ (单选题 *必答)

○ 非常关注
○ 关注
○ 一般
○ 不太关注
○ 不关注

12、他们了解和掌握新型肺炎疫情信息的主要渠道有哪些？ (多选题 *必答)

☐ 报纸
☐ 微博
☐ 朋友圈
☐ 电视
☐ 本地论坛
☐ 微信群
☐ 公众号推送消息
☐ 网站和新闻 APP
☐ 亲友
☐ 其他 _____

13、他们对每日询问健康状况这种应对措施有什么样的评价？ (单选题 *必答)

○ 非常必要
○ 比较必要
○ 一般
○ 不太必要
○ 不必要

14、您家中长辈对健康码这种应对措施有什么样的评价？ (多选题 *必答)

☐ 有效且及时的控制住疫情大范围的传播
☐ 一定程度上在生活上带来了不便
☐ 完全没有必要，形式大于内容

☐ 担忧个人隐私
☐ 不清楚具体使用原因

15、他们是否愿意提供自己的私人数据用于抗击新冠肺炎？ (多选题 *必答)

☐ 愿意提供身体健康数据
☐ 愿意提供行踪轨迹
☐ 愿意提供密切接触者名单和联系方式
☐ 都不愿意

16、您家中长辈是更倾向于以实名还是匿名的方式分享自己的私人数据？ (多选题 *必答)

☐ 实名
☐ 匿名

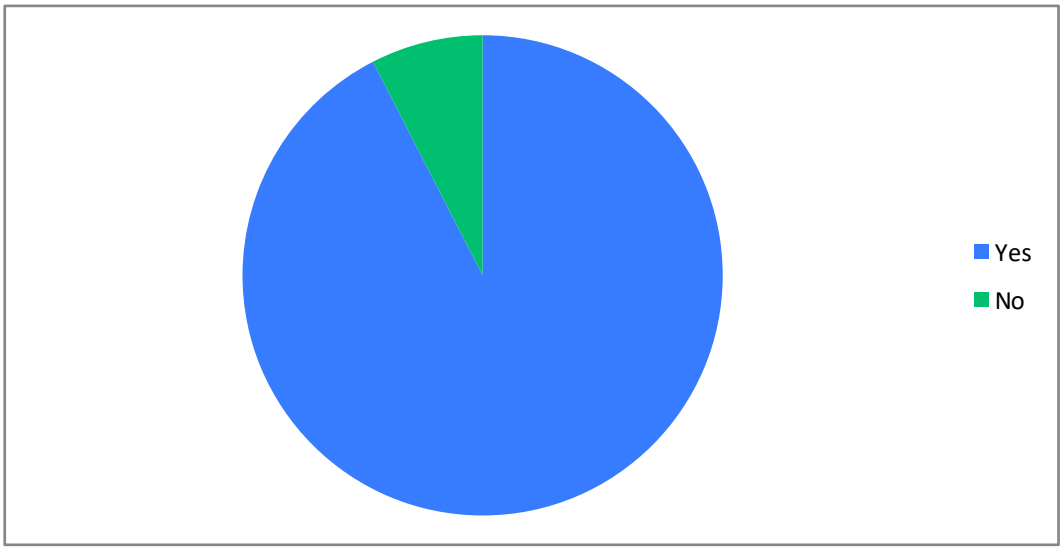
9.3.2 Survey Results

9.3.3 Summary of questionnaire findings

As the results of questionnaires shown, over half of people aged 50 or over have a positive attitude on actively participating in self-reporting (64%) and contributing their health status data (56%). However, comparing to data collection methods for existing real-name monitoring systems, a majority of people aged 50 or over (68%) prefer providing their information in an anonymous approach. Although 47% of participants think health QR code is an eective way to control and monitoring the epidemic of coronavirus, there are still people who's life was negatively eected (23%) and who even do not know why they should use it (23%). Another problem is that people aged 50s or over often have problems when using mobile application individually. In particular, the process of downloading mobile application (47%) and registration(38%), and the content of user interface (45%) are too complex to operation without any helps or training. However, when asked about whether they are willing to give a help, 43% participants expressed that their older family members often forget about the content taught.

9.3.4 Figures

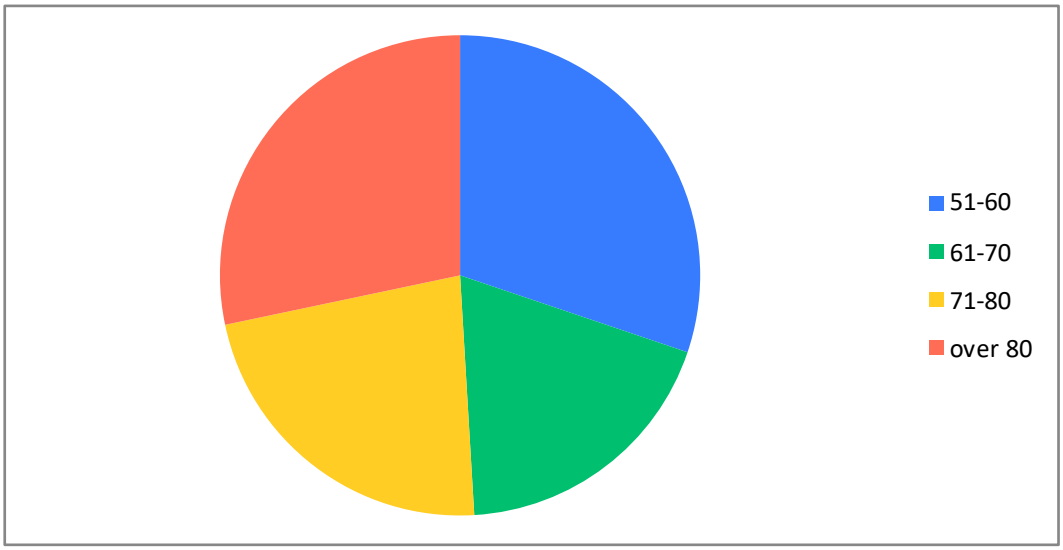
Q1



Option	Numbers
Yes	49
No	4
Totoal	53

下一題

Q2



Option	Numbers
51-60	16
61-70	10
71-80	12
over 80	15
Total	53

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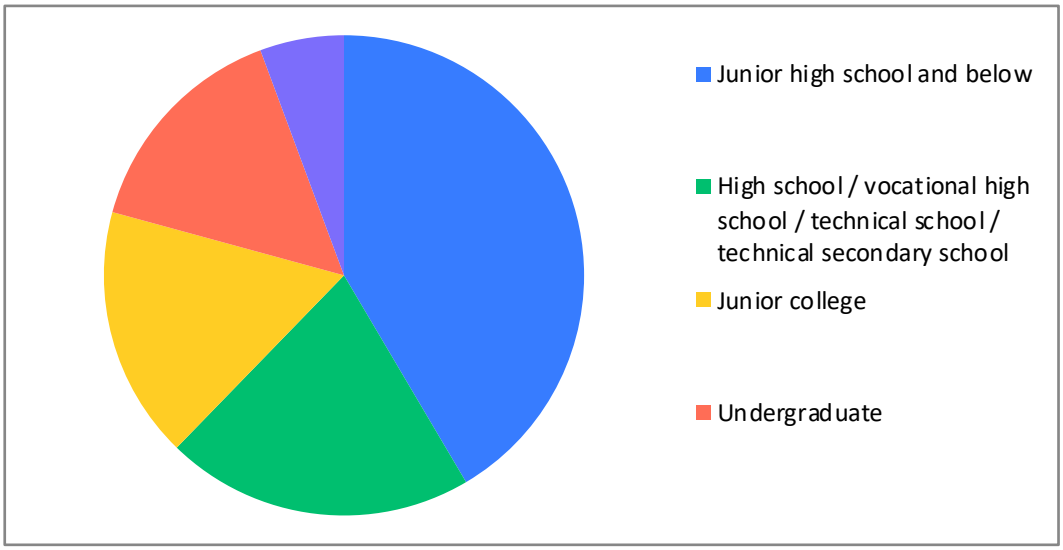
Q3



Option	Numbers
Junior high school and below	22
High school / vocational high school / technical school / technical secondary school	11
Junior college	9
Undergraduate	8
Postgraduate	3
Total	53

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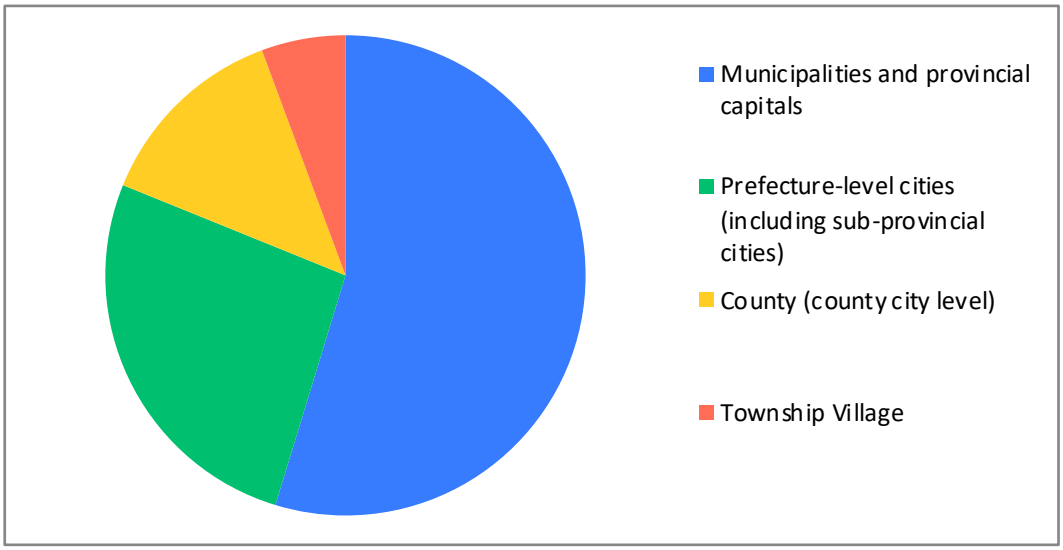
Q4



Option	Numbers
Municipalities and provincial capitals	29
Prefecture-level cities (including sub-provincial cities)	14
County (county city level)	7
Township Village	3
Number of answers	53

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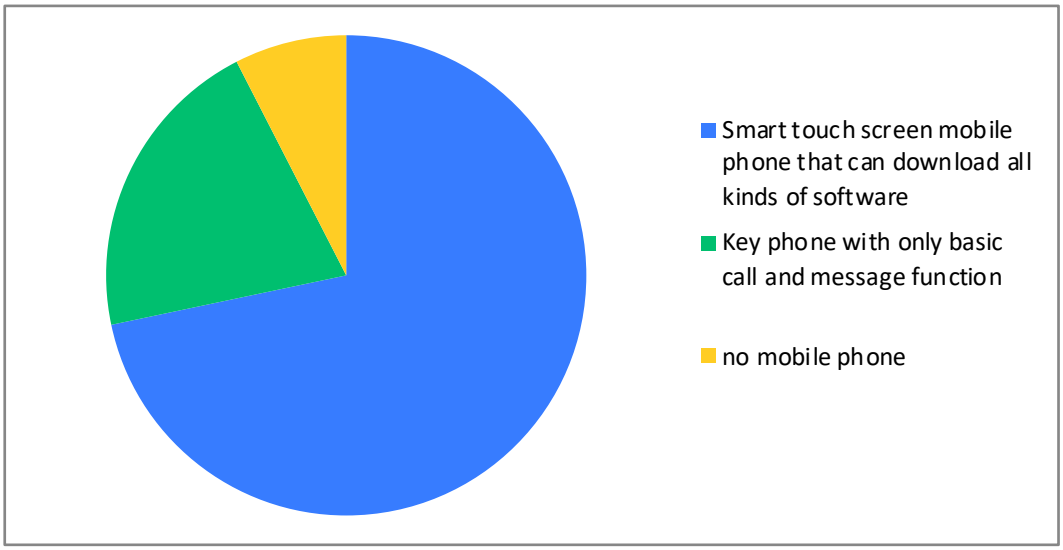
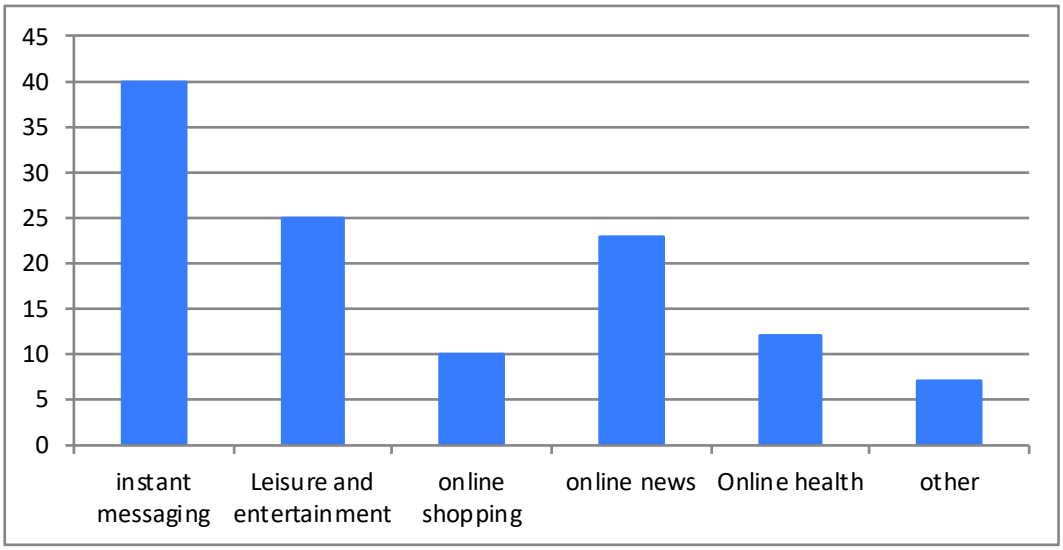
Q5



Option	Numbers
Smart touch screen mobile phone that can download all kinds of software	38
Key phone with only basic call and message function	11
no mobile phone	4
Number of answers	53

上一题　　下一题

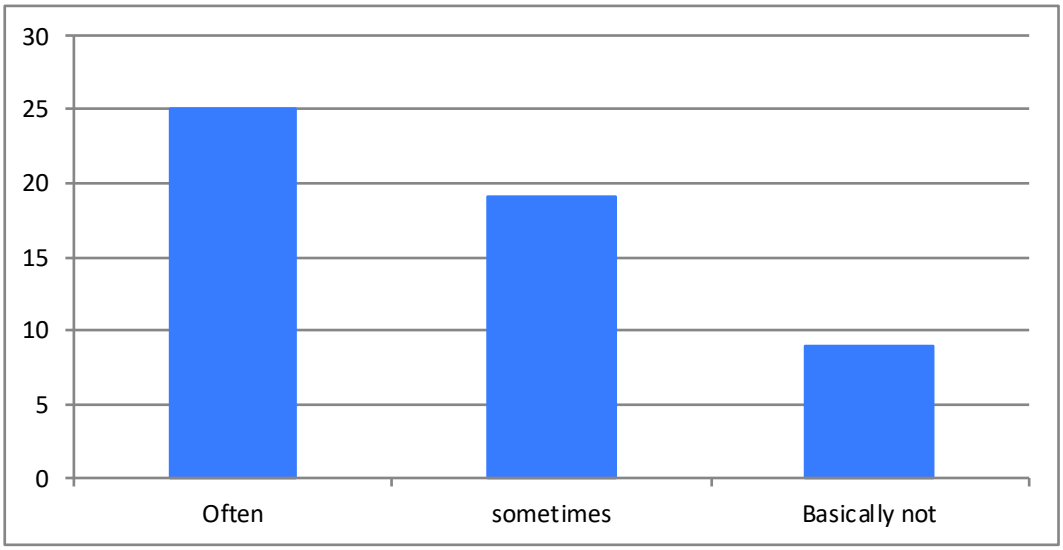
Q6



Option	Numbers
instant messaging	40
Leisure and entertainment	25
online shopping	10
online news	23
Online health	12
other	7
Number of answers	53

上一題 下一題

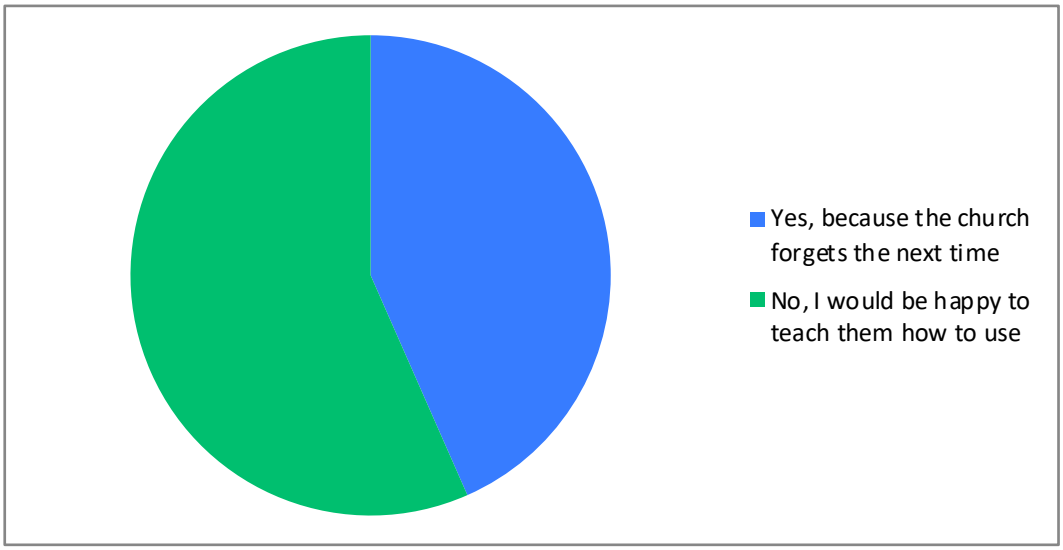
Q7



Option	Numbers
Often	25
sometimes	19
Basically not	9
Number of answers	53

上一題 下一題

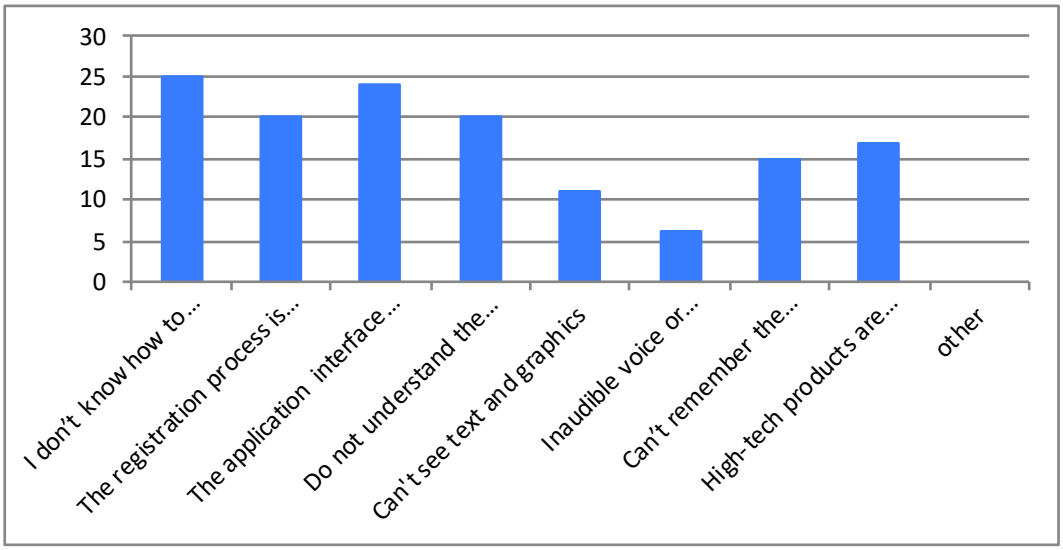
Q8



Option	Numbers
Yes, because the church forgets the next time	23
No, I would be happy to teach them how to use	30
Number of answers	53

上一題　下一題

Q9



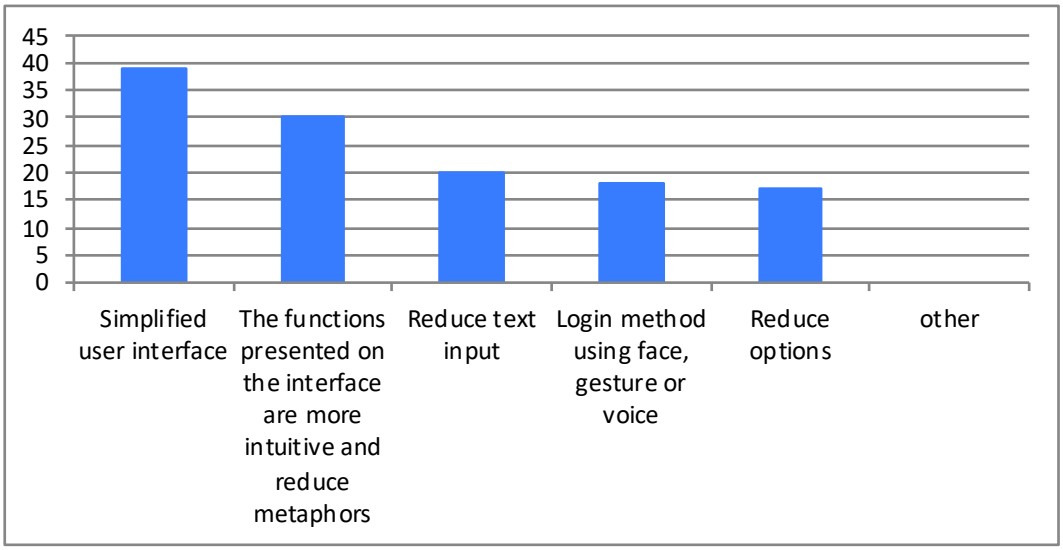
Option	Numbers
I don’ t know how to download mobile apps from Application stores	25
The registration process is more complicated	20

The application interface is too complicated, there are too many choices, and I don’ t know how to operate	24
Do not understand the symbols, graphics or prompts in the operation interface	20
Can't see text and graphics	11
Inaudible voice or prompts can’ t be heard clearly	6

Can’t remember the operation flow when completing a long procedure	15
High-tech products are too difficult to learn	17
other	0
Number of answers	53

上一題 下一題

Q10

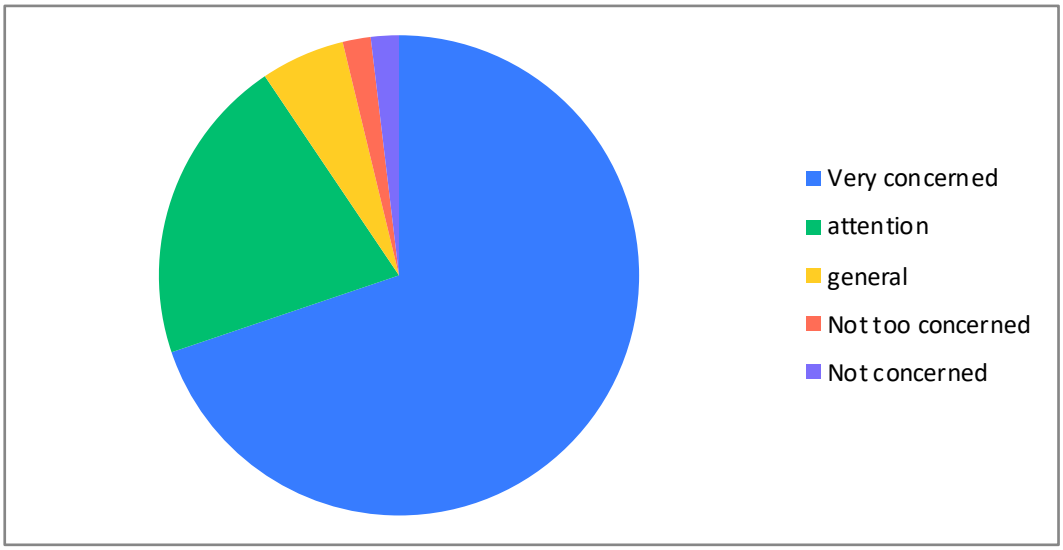


Option	Numbers
Simplified user interface	39
The functions presented on the interface are more intuitive and reduce metaphors	30
Reduce text input	20
Login method using face, gesture or voice	18

Reduce options	17
other	0
Number of answers	53

上一题 下一题

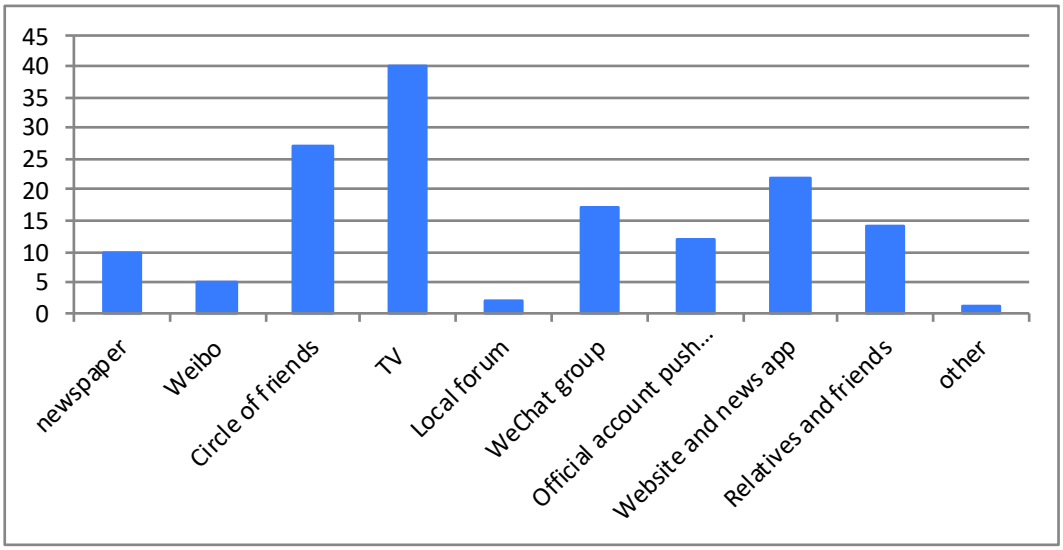
Q11



Option	Numbers
Very concerned	37
attention	11
general	3
Not too concerned	1
Not concerned	1
Number of answers	53

上一題　下一題

Q12



Option	Numbers
newspaper	10
Weibo	5
Circle of friends	27
TV	40
Local forum	2
WeChat group	17
Official account push message	12
Website and news app	22
Relatives and friends	14
other	1

Number of answers	53

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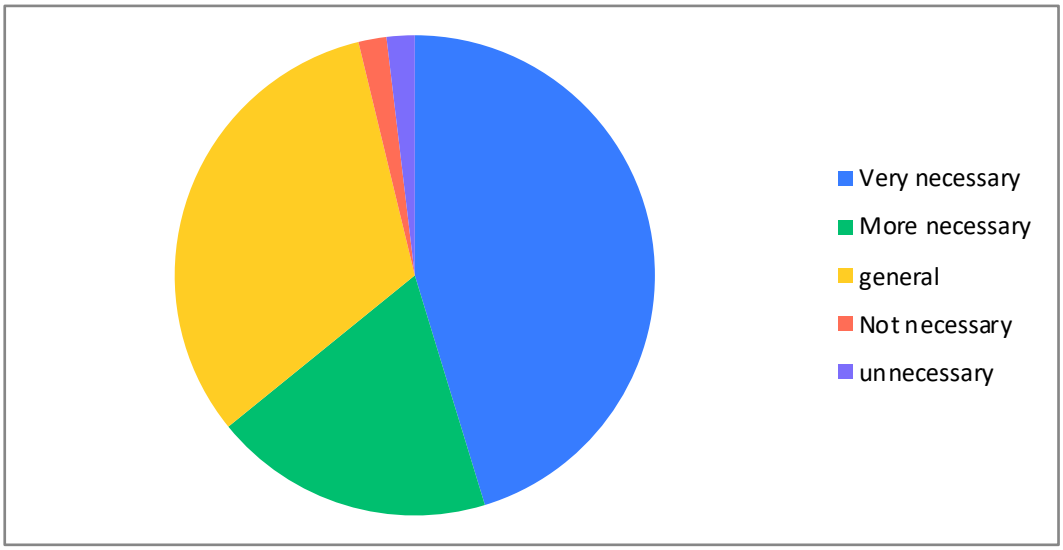
在选项 其他 中填写的内容
没有

Q13



Option	Numbers
Very necessary	24
More necessary	10
general	17
Not necessary	1
unnecessary	1
Number of answers	53

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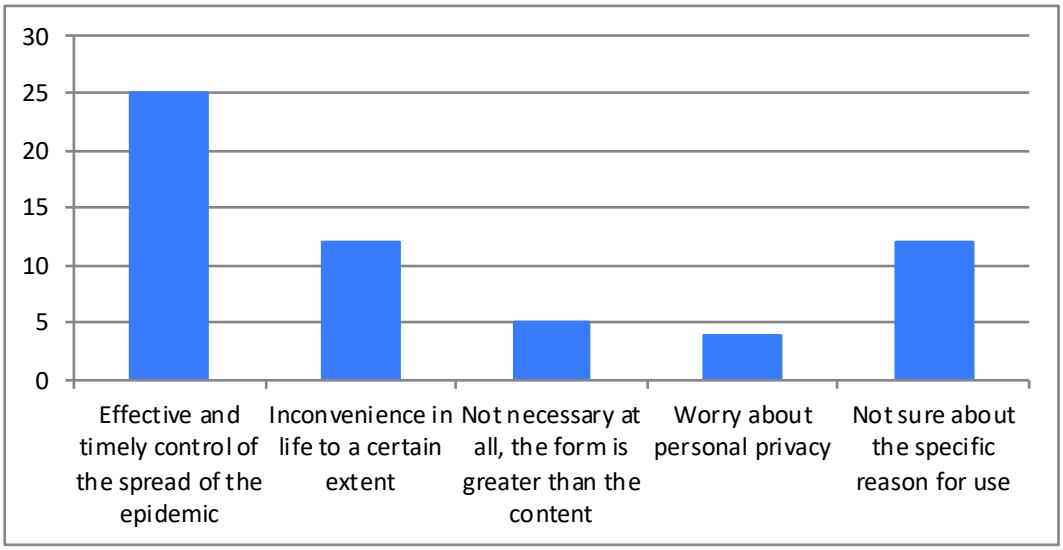
Q14



Option	Numbers
Effective and timely control of the spread of the epidemic	25
Inconvenience in life to a certain extent	12
Not necessary at all, the form is greater than the content	5
Worry about personal privacy	4

Not sure about the specific reason for use	12
Number of answers	53

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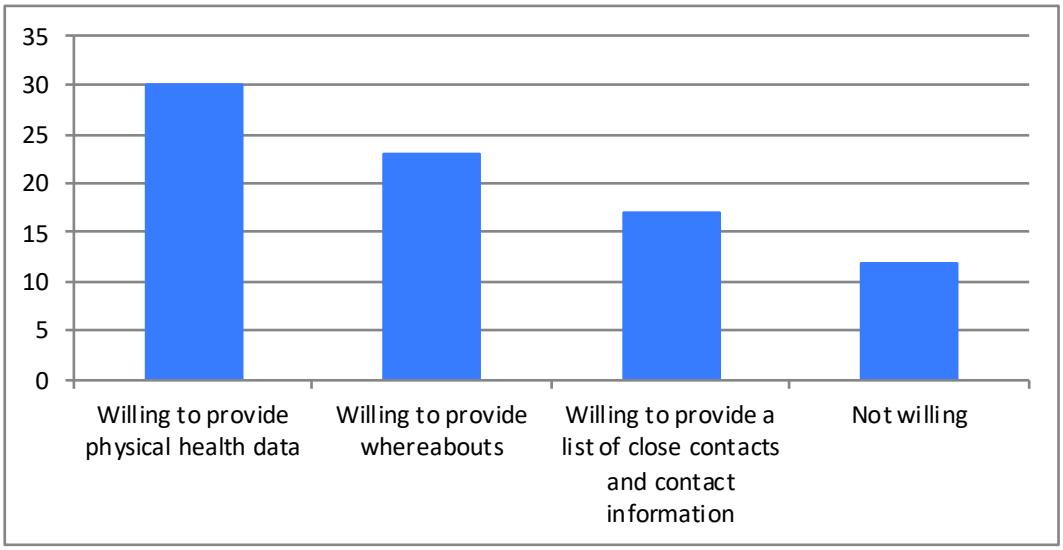
Q15



Option	Numbers
Willing to provide physical health data	30
Willing to provide whereabouts	23
Willing to provide a list of close contacts and contact information	17
Not willing	12

Number of answers	53

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