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RESEARCH ARTICLE

PUBLIC ACCEPTANCE 0F COVID-19 RELATED LOCATION TRACKING TECHNOLOGY WHILE IN QUARANTINE: EVIDENCE FROM SOUTH KOREA

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ABSTRACT

INTRODUCTION:

Since the outbreak of the COVID-19 pandemic in December 2019, public policy debate has been increasingly focusing on developing and implementing new disease prevention measures based on tracking of geographical location, in particular during the quarantine period. Limited studies have so far investigated possible public acceptance of such measures.

METHODS:

We analyzed a sample data of 1,000 respondents from the 2021 Korean Social Science Data Center using descriptive statistics and logistic regression modelling. The outcome variable was the binary variable measuring the public acceptance of COVID-19 related tracking devices for people subjected to quarantine, explanatory variable included socio-economic characteristics and subjective perception measures.

RESULTS:

The results suggest that subjective factors, such as perceived likelihood of virus contraction (OR=1.78) and severity of the disease (OR=2.21), rather than socio-economic factors, are key determinants of public acceptance of COVID-19 related location tracking technology. Elderly participants in the middle socio-economic class have shown the highest acceptance rate for tracking device implementation

CONCLUSION:

Although the use of location tracking devices has been increasing exponentially, there is still limited understanding in terms of public acceptance of such devices. The results of this study contribute to identifying such determinants, this contributing to policy design related to COVID-19 prevention.

KEYWORDS

COVID-19, location tracking, digital health, disease prevention, personal information, South Korea

INTRODUCTION

As of 14 March 2022, 458 million cases of COVID-19 were confirmed including 6.04 million deaths globally [1]. Americas ranked the first for the confirmed cases and is followed by Europe, South-East Asia, Eastern Mediterranean, Western Pacific and Africa [1]. Moreover, as of 14 March 2022, it was reported that around 4.46 billion people (57.2%) have been fully vaccinated worldwide. In East Asia, there have been a cumulative total of 12.8 million cases of COVID-19 with South Korea coming in first, Japan and China in second and third as of 14 March 2022 [1]. There have been many global efforts to contain the spread of highly infectious disease, COVID-19. Governments encouraged people to improve their hygiene standards and took protective measures by closing schools and stores and advising people to stay home [2]. However, due to the emergence of Delta and Omicron variants, the global society is likely to face another crisis.

Information and Communication Technologies (ICT) are products that store, process, transmit, convert, duplicate, or receive electronic information. ICT is especially useful when it comes to tracking individuals who are in contact with coronavirus patients. One study argues that epidemic trackers must be prepared to track primary, secondary, and tertiary contacts of the people who have tested positive by using data analytics and data management technology [3]. This means that ICT makes it easier for medical personnel to track down people and prevent the further spread of the disease. Another study revealed that mandatory mobile tracking and monitoring of individuals who are or potentially COVID-19 positive can reduce further cases a day by 3.3 on average, holding other things constant [4].

In South Korea, as of 14 March 2022, a cumulative total of 6,866,222 cases were reported with 9,875 deaths [5]. On the same day, 309,790 domestic cases and 62 new foreign cases were confirmed. Among the 309,790 confirmed cases, Gyeonggi province accounted for 28.4% followed by Seoul 22.4%, Busan 7.7%, and Incheon 6.7% [5]. As of 14 March 2022, the government eased social distancing regulations due to low fatality rate and to revive the economy. However, before this happened, the South Korean government's reaction to contain the spread of the pandemic received a lot of praise. According to a recent study, when it comes to publicizing data, South Korea took a maximalist approach, which was judged as a necessary and efficient prevention measures, but also resulted in some personal data protection issues [3]. Those who were in contact with coronavirus patients and asymptomatic were advised to be in quarantine and report their status on applications. As of 14 March 2022, an overwhelming number of cases made it difficult for the country to contain further spread of COVID-19 as Omicron swept the country.

A recent study [6] stated that there was an extensive use of South Korea's advanced information technology system for tracing people who are suspected to be infected or who had been in contact with an infected person. South Koreans were also required to use cameras and apps on their phones to scan a QR code to enter places and their phone numbers were sent to the government to notify their presence in crowded places [7]. A recent study on South Korea's responses to COVID-19 found that mobile applications for tracking self-quarantine and self-check-in apps were pivotal in enabling the systematic management of government responses [8]. The apps made it easier for GPS trackers to identify infected people and know their symptoms in advance by lessening the procedure of having to do patients' on-site health questionnaires [8]. These measures also reduced the burden on contract tracers and enabled alert of exposure via SMS.

There have generally been mixed responses to the use of location tracking technologies. One recent study found that people showed favorable response to adopt novel location-tracking systems (e.g. SimSense) as long as the system is transparent about its data collection and ownership and reflects users' tracking preferences [9]. However, another study conducted amongst the group of 2,000 adult Americans revealed that there was more support for contact tracing, which did not disclose users' location [10]. The authors point out that people might have distrust towards some official policies, tech companies, or third parties that can facilitate or gain access to personal data. In South Korea, some people suffered from disclosure of their private information, with some coronavirus patients being mentally hurt from the public disdain caused by the unwanted privacy invasion [6].

While there is already a growing body of literature on the use of ICT in disease prevention context, there is still limited evidence regarding the public acceptance of COVID-19 related location tracking technology with the empirical data from South Korea. To fill this gap, the present study provides an analysis of survey data of public acceptance of COVID-19 related location tracking technology focusing

specifically on the individual subject to quarantine. The findings of this paper are expected to contribute to the ongoing debate and policy design regarding potential use of location tracking technology.

DATA AND METHODS

THE DATASET

This study used data from the Public Perception Survey on COVID-19 Self-quarantine survey which was designed and implemented by Korean Social Science Data Center (KSDC). It applied proportional sampling method and random selection based on regions, gender, and age. The survey was undertaken on April 8th and 9th, 2020. After proportional allocation by region, gender and age, random sampling was used. The confidence interval was set at 95% and the maximum allowable sampling error was ±3.1%. To conduct the interviews, both CAWI (Computer Assisted Web Interview) and CAMI (Computer Assisted Mobile Interview) systems were used [11].

In total, 1,000 respondents were interviewed from Seoul, Incheon, Gyeonggi, Daejeon, Chungcheong, Sejong, Gwangju, Jeolla, Daegu, North Gyeongsang, Busan, Ulsan, South Gyeongsang, Gangwon, and Jeju. Among the respondents, 493 were males and 507 were females. Incheon and Gyeonggi accounted for 30.7% of the sampled respondents by regions with Seoul coming in second, Busan, Ulsan, South Gyeongsang; in third, Daejeon, Chungcheong, Sejong; in fourth, Daegu, North Gyeongsang; in fifth, Gwangju; Jeolla in sixth; and Gangwon / Jeju in last place.

The dependent variable in this study was the willingness to accept being tracked by a location device during the quarantine period. The device was defined as a wrist-worn electronic device that tracks real-time location of people subject to quarantine with smart app usage. The independent socio-economic variables included age ('above 60' and '60 or less'), education (primary, secondary, and tertiary), gender (male and female), geographical location (SMA and other), socio-economic class ('upper or upper middle', 'middle', and 'low or lower middle'), working status (working and not working). Subjective perception factors included the measure of how serious people think of the domestic spread of COVID-19 ('serious or very serious' and 'not serious or neutral'), and the perceived likelihood of contraction ('very likely or likely' and 'very unlikely or unlikely or even chance').

The relevant parts of the survey questionnaire (variables used in the analysis) are provided as a supplementary file (Supplementary file 1).

TABLE 1 DISTRIBUTION OF SAMPLED RESPONDENTS BY THE GEOGRAPHICAL REGION

Geographical region	Frequency	Percent
Seoul	192	19.2
Incheon / Gyeonggi	307	30.7
Daejeon / Chungcheong / Sejong	107	10.7
Gwangju / Jeolla	99	9.9
Daegu / North Gyeongsang	101	10.1
Busan / Ulsan / South Gyeongsang	151	15.1
Gangwon / Jeju	43	4.3
Total	1,000	100

Source: KSDC, 2021

STATISTICAL ANALYSIS

The data was examined using descriptive statistics (frequencies, chi-square test) and statistical modelling. Given the distribution of the data and binary nature of the outcome

The logistic regression models are used when dependent variables are discrete, i.e., when dependent variables have more than one mutually exclusive category, and in the case of binary logistic regression the target variable should be binary [12, 13]. These models presuppose that each option can be described by a utility function that

depends on the attributes of the option and on the characteristics of the individual. The binary logistic regression model is as follows.

$$\text{logit}(\pi) = \beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \beta pXp + e$$

where $\beta 0, \beta 1, \ldots, \beta p$ are logit regression parameters; $X1, X2, \ldots, Xp$ are independent variables (explanatory variables), and π is the probability of success.

Binary logit model generally measures the proportion to predict the probability of belonging to two groups (e.g., the acceptance intention group as 1 and the acceptance intention unclear or rejection group as 0). Here, π is the probability that the respondent selects '1 (acceptance group)' and 1-π is the probability that the respondent selects '0 (acceptance unclear or rejection group). In this state, the logit model taking natural logarithm on both sides can be calculated and displayed as a general regression relationship as follows.

$$log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X$$

The goal of logistic regression is to predict the "true" proportion of success, π, at any value of the predictor. Logistic regression results are parsed using odds ratio (OR) and its 95% confidence interval.

Finally, the specific reasons for supporting or opposing the introduction of a wrist-worn electronic device that tracks real-time location during quarantine was analysed graphically using a bar chart.

RESULTS

Overall, most survey participants supported the idea of having a tracking device attached, although this support was slightly lower amongst the individuals over 60 (83.91% vs. 85.61% for individuals aged 60 or lower). However, based on the results of chi-square test, neither age, education, gender or working status were significantly associated with the perception towards COVID-19 related location tracking. On the other hand, socio-economic status, perceived likelihood of virus contraction and its perceived severity were all significant at different significance levels. More specifically, compared to other socio-economic classes, survey respondents from the middle socio-economic class showed the highest support (87.62%) for potential implementation of tracking devices. In addition, the vast majority of the respondents who considered the contraction of the virus as likely or very likely and its severity as serious or very serious would agree to a policy implemented COVID-19 related tracking devices (91.19% and 87.17% respectively).

TABLE 2 PERCENTAGE OF RESPONDENTS AGREED TO ACCEPT A TRACKING DEVICE ATTACHED BY THEIR DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS

	Agree n(%)	Disagree n(%)	p-value
Age			0.513
Above 60	219 (83.91)	42 (16.09)	
60 or less	571 (85.61)	96 (14.39)	
Education			0.845
Primary	14 (82.35)	3 (17.65)	
Secondary	362 (84.58)	66 (15.42)	
Tertiary	414 (85.71)	69 (14.29)	
Gender			0.319
Male	393 (83.97)	75 (16.03)	
Female	397 (86.30)	63 (13.70)	
Geographical location			0.206
SMA	200 (82.64)	42 (17.36)	
Other	590 (86.01)	96 (13.99)	

Socio-economic class			0.070
Upper or middle-upper	75 (78.13)	21 (21.88)	
Middle	283 (87.62)	40 (12.38)	
Middle-low or low	432 (84.87)	77 (15.13)	
Working status			0.919
Working	483 (85.04)	85 (14.96)	
Not working	307 (85.28)	53 (14.72)	
How serious			0.000
Serious or very serious	686 (87.17)	101 (12.83)	
Not serious or neutral	104 (73.76)	37 (26.24)	
Likelihood of contraction			0.008
Very likely/likely	176 (91.19)	17 (8.81)	
Very unlikely, unlikely or even chance	614 (83.54)	121 (16.46)	

Note: Chi-square test was performed for all categorical variables.

Regarding the determinants of the public acceptance of tracking devices (Table 3), it can be observed that socio-economic characteristics are generally less important compared to subjective factors, such as perception of the seriousness of virus contraction and the likelihood of contraction. Thus, for respondents who believed that contracting the various was a serious or very serious matter where, the odds of accepting a tracking device were 2.21 times as large as the odds for accepting such a device by respondents who did not share this view. Similar, compared to other respondents, the odds of accepting an electronic tracking device were significantly higher (OR=1.78) for respondents who believed that contracting the virus was very likely or likely. When considering only the elderly respondents (65+), the socio-economic class was also a significant predictor of public acceptance of COVID-19 tracking devices. More specifically, compared to other elderly respondents, elderly respondents from lower-middle and low socio-economic classes were significantly more likely to accept such a device (OR = 3.02).

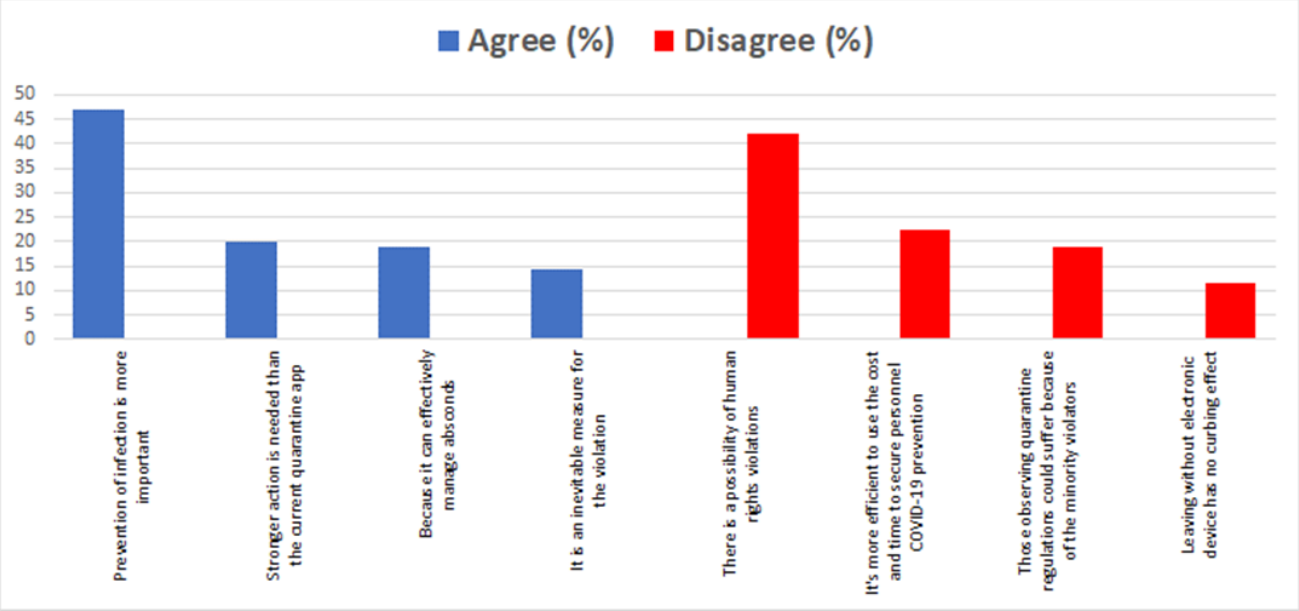
Survey data also provided information about the detailed reasons for agreeing or disagreeing to have an electronic tracking device attached. The illustrative summary of responses is presented in Figure 1. it can be noticed that the respondents who do support implementation of location tracking devices see these as an important virus spread prevention method stating that "Prevention of infection is more important" (46.82.% of those supporting the tracking devices measure). On the other hand, respondents who oppose such measure cite human rights violation as a key reason against electronic tracking devices (42.03% of all the respondents opposing this measure quote this reason). The top four reasons for instance are presented in Figure 1.

TABLE 3 FACTORS ASSOCIATED WITH ACCEPTANCE OF AGREEING OR DISAGREEING TO ATTACH ELECTRONIC TRACKING DEVICES USING LOGISTIC REGRESSION MODELS

DV: Public acceptance of COVID-19 related location tracking technology	Model 1 (all respondents)	Model 2 (elderly respondents)
	OR (95% CI)	OR (95% CI)
Age		
Above 60	0.882 (0.578-1.345)	
60 or less	0.00	
Education		
Primary	0.00	0.00
Secondary	0.943 (0.259-3.432)	1.550 (0.365-6.593)

Tertiary	1.029 (0.279-3.797)	3.655 (0.741-18.022)
Gender		
Male	0.00	0.00
Female	1.165 (0.789-1.719)	1.751 (0.796-3.852)
Region		
SMA	0.753 (0.504-1.125)	1.355 (0.595-3.090)
Other	0.00	0.00
Socio-economic class		
Top	0.00	0.00
Middle	1.740 (0.969-3.125)	2.210 (0.663-7.371)
Lower-middle and low	1.43 (0.821-2.49)	3.018 (0.930-9.800)*
Working status		
Working	0.981 (0.651-1.478)	0.959 (0.432-2.126)
Not working	0.00	0.00
How serious		
Serious or very serious	2.206 (1.425-3.414)***	3.632 (1.582-8.334)***
Not serious or neutral	0.00	0.00
Likelihood of contraction		
Very likely/likely	1.776 (1.028-3.067)**	1.776 (0.698-14.251)
Very unlikely, unlikely or even chance	0.00	0.00
Constant	2.042 (0.483-8.629)	0.034 (0.234-1.728)

FIGURE 1 REASONS FOR AGREEMENT OR DISAGREEING TO ATTACH ELECTRONIC TRACKING DEVICES (TOP 4)



DISCUSSION AND CONCLUSION

This study aimed at investigating the factors determining the public acceptance of COVID-19 related location tracking devices in South Korea, specifically focusing on the quarantine period. The results revealed that age, education, gender, and working status showed no significant association with the perception towards such

devices. On the other hand, socio-economic status, perceived likelihood of virus contraction and perceived severity were significantly associated with the respondents' perception of location tracking devices. Elderly participants in the middle socio-economic class has shown the highest support for tracking device implementation while in quarantine. Those who thought that virus contraction was likely or very likely and perceived severity of the virus, were likely to agree to a policy implementing COVID-19 related tracking devices. People who supported implementation of electronic tracking devices considered it as important virus spread prevention method while others opposing the measure stated that using the device was a human rights violation.

One recent study from South Korea examined to the usage of various COVID-19 related apps (including apps showing where diagnosed patients were found) by dividing the data periods into three phases; before the peak of the first wave, during the peak, and after the peak [14]. The results showed that there was a high likelihood of adoption of such apps by people with higher education before the peak of the first wave [12]. Then, during the peak, people with higher income tended to adopt the apps. After the peak, people with higher education levels were more likely to adopt the apps [12]. On the other hand, low-income respondents were prone to utilize COVID-19 apps more frequently even though they tended to use COVID-19 apps late [14]. Moreover, the findings indicated that younger respondents as well as respondents with lower income and lower education levels were less likely to adopt COVID-19 apps [14]. In our study, we did not find significant age effects, however our study did not use a detailed age classification, which might be considered in future research.

On a slightly different, but related topic of contact tracing apps, a study conducted on a sample size of 1,963 respondents in the U.S. found that gender, household income, education, age, and residence had significant effects on app adoption intentions [15]. Females had significantly lower intentions to adopt the app, high household income showed significant positive effects on intentions to install the app and keep the app installed, higher education had significant positive effects on intentions to keep the app installed particularly when the COVID-19 cases were rising, older people had significantly lower intentions to install the app, and people who are frequent public transit users and people who live in urbanized area had significantly higher adoption intentions [15].

While contact tracing and location tracking are key elements of diseases prevention strategies [16], it should be noted that they often have important privacy and ethical concerns. A number of existing studies [e.g., 16, 17, 18] already raised important concerns around anonymity of the data. Higher research also highlighted that privacy concerns vary amongst countries, compared to South Koreans for example respondents in the USA were found to be less likely to consider control measures acceptable [18]. This was explained by a stronger collectivist culture and perceived social benefits of COVID-19 prevention measures involving location tracking [18].

Considered as an unprecedented crisis in human history, the COVID-19 pandemic has without doubt compelled many governments to implement radical measures including location tracking technologies [19, 20] to help control the spread of the virus. These measures have however raised significant personal security risks and breaches [21], human rights and individual freedom violation, fears of surveillance [22, 23, 24, 25] as well as dwindling public trust in government [26]. Whiles individual data-breaches might be inevitable and do not disappear especially during crisis such as COVID-19, data protection, data governance, security, and human rights issues must always be upheld as important values. Addressing these concerns calls for key policy measures which include – ensuring high personal data security; promoting data privacy and anonymity; upholding transparency, building public trust and voluntary acceptance of such technologies as attested by recent studies [20, 27]. It should be noted that stringent and involuntary enforcement of such intrusive location tracking technologies has a tendency of increasing individual stress, anxiety and possible worsening mental health and wellbeing.

This study is not without limitations. First, the study was conducted during the first wave of the pandemic and since then, especially given the recent peaks due to omicron cases, public perception might have changed. Secondly, the study did not ask detailed questions about the potential tracking devices as well as questions related to use and storage of potentially collected data. It would be useful if future research considered designing a more comprehensive survey which among other things would explore the influence of religion, cultural belief systems, and

political orientation of people on the acceptance of COVID-19 related location tracking technologies.

This study is helpful in that it identifies the determinants of public acceptance of location tracking devices in the context of COVID-19 prevention. Although the use of tracking devices has been increasing significantly, the current legal system and public awareness are not up to speed to deal with the potential consequences of such extensive use. The law stipulates that information, such as travel routes should be disclosed only when necessary to prevent infectious diseases, however once reported to the media or through text messages, the personal information exposure becomes inevitable [28]. This might inflict damage on many individuals since they unwillingly have to reveal their private information, including details of daily activities [28]. Therefore, this paper depicts the characteristics of COVID-19 infections in South Korea and the empirical results act as a guide that enables policymakers to take proper action to contain the pandemic.

CONFLICT OF INTEREST:

We declare no conflict of interest.

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SUPPLEMENTARY FILE 1

SURVEY QUESTIONNAIRE (VARIABLES USED IN THE ANALYSIS)

Q1. Choose the region you live in.
Seoul=1, Busan=2, Incheon=3, Gwangju=4, Daejeon=5, Ulsan=6, Gyeonggi=7, Gangwon=8, Chungbuk=10, Chungnam=11, Jeonbuk=12, Jeonnam=13, Gyeongbuk=14, Gyeongnam=15, Jeju=16, Sejong=17
Q2. What is your sex?
Male=1, Female=2
Q3. How old are you?
19-29=1, 30-39=2, 40-49=3, 50-59=4, Over 60=5
Q4. What educational background do you possess? Please respond based on your graduation.
Middle school graduate or below=1, High school graduate=2, Attending university/University graduate or higher=3
Q5. What do you think of attaching wrist-worn electronic device to those who are subject to quarantine by using smart app to check the real-time location of them?
agree=1, disagree=2, I don't know=3
Q6. What is your main reason for this measure?
Prevention of infection is more important=1, Stronger action is needed than the current quarantine app=2, Because it can effectively manage absconds=3, It is an inevitable measure for the violation=4, No problem will arise as it is being used in some foreign countries=5, Other=6
Q7. What is the main reason against this measure?
There is a possibility of human rights violations=1, The rate of absconds is low during quarantine and the existing quarantine system might be enough=2, Leaving without electronic device has no curbing effect=3, Majority who observe the quarantine regulations could suffer because of the minority violators=4, It's more efficient to use the cost and time to secure personnel for prevention of COVID-19 than to make electronic devices=5, Other=6
Q8. How serious do you think the domestic spread of COVID-19 is?
Not serious at all=1, Not that serious=2, Neutral=3, Serious=4, Very serious=5
Q9. What do you think are your chances of contracting COVID-19?
Very unlikely=1, Unlikely=2, Even chance=3, Likely=4, Very likely=5
Q10. What is your occupation?
Agriculture/forestry/fishery=1, Self-employment=2, Sales/business/service work=3, Production/profession=5, housewife=6, student=7, unemployed/retired/other=8
Q11. Which of the following do you think is your socio-economic class?
Top=1, Mid-high=2, Middle=3, Middle-low=4, Low=5, I don't know=6