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Improvement of Data Sending Rate and Survey Completion Rate of Smartphone-based Travel Surveys in Two Afghanistan Cities

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Abstract

Transportation researchers and planners have been attempting to use the smartphone-based travel survey for detailed and accurate travel data collection. Increasing the number of survey participants is important to obtain valid and effective results. Special attention is necessary as both the number of consenting participants and the number of respondents who sent data and remained until the completion of the survey are important in this survey. This study aims to investigate the data sending rate and survey completion rate of smartphone-based travel surveys. We conducted a smartphone-based travel survey in 2015 and two surveys in 2017, in Afghanistan cities. We improved the recruitment method used in 2017, when compared with the method used in 2015. The improvements included incentive provision, female survey conductors to recruit females, and assistance for the installation and running of the application. It was found that these improvements significantly increased the data sending rate, but the effects on the survey completion rate were limited. The long-time smartphone users, respondents in the local city and employed respondents were also found to stay longer in the survey.

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Keywords: smartphone-based travel survey, data sending rate, survey completion rate, recruitment method

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1. Introduction

Since the appearance of smartphones on the market as versatile and ubiquitous products, their use as data collection tools has attracted significant attention from transportation researchers, planners, and policymakers. The technology embedded in smartphones provides the opportunity to accurately collect the travel data of individuals. In the traditional survey methods, respondents typically record their information from memory. There is therefore the possibility of missing trips and errors in time and location information. These errors can be reduced and minimized by using smartphones for the purpose of travel data collection (Adrian et al. 2018; Allstrom et al. 2017; Greaves et al. 2015; Safi et al. 2015; Sato and Maruyama 2018). In addition, smartphones enable respondents to record multi-day travel information without additional costs or the incurrence of large survey burdens (Asakura et al. 2014; Shin et al. 2015; Zhao et al. 2015).

Despite the advantages of the smartphone-based travel survey mentioned above, there are still some technological and respondent-related challenges that need to be considered. For example, the accuracies of data collected through web-based, GPS, and two smartphone-based travel surveys were compared by Safi et al. (2017). The results revealed that an appropriate application of smartphones can enhance the accuracy of data, whereas the inappropriate use of smartphone applications can adversely affect the data accuracy. Additionally, there are several respondent-related challenges with respect to the smartphone-based travel survey. For instance, survey burden, privacy, and battery life are the main concerns of respondents in this survey (Bhat 2015; Cottrill et al. 2013; Danalet and Mathys 2017, Ketelaar and Van Balen 2018; Montini et al. 2015; Nitsche et al. 2012; TRB Travel Survey Method Committee 2013; Zegras et al. 2018). These concerns can negatively affect the response rate of the smartphone-based travel survey. If the response rate of the survey is low or the sample size is small, the validity of the survey results is limited.

Considering these issues, transportation researchers in developed countries are striving to use different strategies (e.g., offering incentives) to enhance the response rate of the smartphone-based survey method (Maruyama et al. 2015). However, the implementation of smartphone-based travel survey and the sample improvements strategies are new issues in developing countries.

As a case in developing countries, we conducted a smartphone-based travel survey in 2015 and two surveys in 2017, in Afghanistan cities. In the 2015 survey that was conducted in the capital city of Kabul, no strategies were used to increase the survey sample size. Hence, the response rate of the survey was low (37.5%) (Qudratullah et al. 2019). Then we improved the recruitment method and conducted two smartphone-based travel surveys in the capital city of Kabul and the local city of Khost. Incentive provision, female survey conductors to recruit females, and assistance for the installation and running of the application were the improvements of the recruitment method considered in the 2017 surveys. One of our previous studies have reported the effects of survey method improvements on response rate (Qudratullah and Maruyama 2019b). We found that the overall response rate was significantly increased by the improved survey recruitment method. The results of that study further revealed that incentives increased the male response rate, whereas the female response rate was improved by the presence of female survey conductors. Moreover, one of our studies have also investigated the reasons of non-response to smartphone-based travel survey (Qudratullah and Maruyama 2019a). The results revealed that a small reward was the dominant reason of male non-response. Whereas the female non-response was mainly generated by privacy concerns, as well as their dependency of making decision-rights since they were not allowed for cultural reasons to make decision for their participation.

Increasing the response rate of the survey is important to obtain valid and effective results. Special attention is required here, in that not only the number of consenting participants, but the number of respondents who sent data and remained until the completion of the survey are important in this survey. In other words, for collecting reliable travel data, the data sending and survey completion rates of respondents are two important factors in smartphone-based travel surveys. The data sending rate of a travel survey is defined as the ratio of participants who have sent the data of at least one day over the total number of consenting participants. The survey completion rate in this study is the ratio of participants who have successfully submitted the data for the requested period (14 days in this case) over the total number of respondents who have started sending the data.

There is a large possibility that the respondents may intentionally withdraw or fail to send data for several reasons. Additionally, the respondents who start sending data may stop sending it before the completion of the requested period of the survey. These behaviours may vary among participants, dependent on their gender, age, occupation, etc. Therefore, there may be different participant tendencies with respect to the survey completion rate, the data sending rate, and the response rate.

The effect on data sending rate and survey completion rate are still remain unreported in our previous studies

(Qudratullah et al. 2019; Qudratullah and Maruyama 2019a, 2019b). Qudratullah et al. (2019) reported and analyzed the 2015 survey data only, and Qudratullah and Maruyama (2019a) analyze non-response reasons using the 2017 survey data. Qudratullah and Maruyama (2019b) analyze the response rate (not including data sending rate or survey completion rate) of the 2015 and 2017 surveys. Thus, this paper focus on the unreported and important topics of the data sending rate and survey completion rate. Hence, the following are the objectives of this study:

1. The investigation of the effects of the survey recruitment method improvement on the data sending rate and survey completion rate of smartphone-based travel surveys in Afghanistan cities.
2. The comparison of the data sending rates and survey completion rates of the surveys conducted in the local city of Khost, and the capital city of Kabul, in Afghanistan.

In developed countries, several studies have been conducted to investigate the causes that could affect the response rate, data sending rate, and completion rate of smartphone-based travel surveys. With respect to the response rate, Maruyama et al. (2015) investigated the effects of incentives on the response rate of a smartphone-based travel survey conducted in 2013 in the city of Kumamoto, Japan. An incentive of 500 JPY (approximately 5 USD) was offered to each respondent. The findings revealed that incentives can significantly increase the response rate. Furthermore, a smartphone-based travel survey conducted in 2014 in New Zealand, reported by Safi et al. (2015) revealed that the response rate was lower than the data sending rate and survey completion rate. In the other words, the individuals were more likely to reject participation in the recruitment period. However, those who consented to participate were more likely to send the data and remain until the end of the survey period. In addition, Safi et al. (2017) reported the factors that possibly affect the survey completion rate. The results of this study revealed that device malfunction and battery consumption are the dominant reasons for the decreased completion rate in smartphone-based travel surveys. Larose and Sandy Tsai (2014) reported an analysis on an online survey that is similar to the smartphone-based survey. This study compared the completion rates under the conditions of no rewards, pre-paid rewards, and sweepstakes. The results of this study revealed that pre-paid rewards were more effective in improving the survey completion rate, when compared with the other two methods. However, the effects of survey recruitment improvements on the data sending rate and completion rate of smartphone-based travel surveys have not been investigated in developing counties. Therefore, the originality of this study is in the investigation of the effect of survey recruitment method improvements on the data sending rate and survey completion rate of smartphone-based travel surveys in Afghanistan, as a case study of developing countries.

This paper is structured as follows: Section 1 is the introduction, and is followed by a description of the method in Section 2. The results are presented in Section 3, and the discussion and conclusions are presented in Sections 4 and 5, respectively.

Table 1. Overview of surveys' sample (From recruitment to survey completion)

Survey city and year		n	%	%	%
Kabul (2015)	**Total recruited**	200	100		
	Non-consenting	125	62.5		
	Consenting	75	37.5	100	
	Not sent data	27		36.0	
	Sent data	48		64.0	100
	Not completed survey period	27			56.2
	Completed survey period	21			43.8
Kabul (2017)	**Total recruited**	137	100		
	Non-consenting	51	37.2		
	Consenting	86	62.8	100	
	Not sent data	16		18.6	
	Sent data	70		81.4	100
	Not completed survey period	43			61.4
	Completed survey period	27			38.6
Khost (2017)	**Total recruited**	218	100		
	Non-consenting	131	60.1		
	Consenting	87	39.9	100	
	Not sent data	21		24.1	
	Sent data	66		75.9	100
	Not completed survey period	32			48.5
	Completed survey period	34			51.5

2. Methodology

We conducted three smartphone-based surveys in two cities of Afghanistan in 2015 and 2017. An existing application named MOVEs was used to record the daily movement of individuals. This application was freely available in the App store and Google play for the iOS and Android platforms, respectively.

In August 2015, one of our first smartphone-based travel surveys was conducted in the capital city of Kabul, Afghanistan. In this survey, no strategy was used to increase the number of participants. The survey team consisted of male personnel (there were no female survey conductors), and individuals were invited through their personal networks. A web-based questionnaire was then sent to consenting individuals to record their socio-demographic information (age, gender, address, vehicle ownership, employment classification, such as government worker, private organization staff, self-employed, housewife, student, etc.) and mode of commuting transport. In addition, the URL of the application, a complete survey guide and privacy policy, and an ID and a password to create the account were also sent to the consenting individuals. They were then requested to download and install the app on their smartphones, and create an account using the provided ID and password. The respondents were also requested to run the application for two weeks. The application enables respondents to record the data and send it to the server once every 24 hours. Our survey team then downloaded the data from each respondent using the provided ID and password. Since the survey team consisted of males, owing to cultural restrictions, the number of consented female participants was small (N=26) in comparison to the number of male participants (N=49).

In 2017, we conducted two more smartphone-based travel surveys in the city of Kabul and the local city of Khost. The data collection was started in September and continued for two months. The socio-demographic information (age, gender, address, vehicle ownership, employment classification, such as government worker, private organization staff, self-employed, housewife, student, etc.) of consenting participants were recorded using a paper-based questionnaire.

Each participant was given face-to-face instructions regarding the use of the application. In addition, the printed documents consisted of privacy policy and the guideline for using the application, and objectives of the survey were provided for each participant. The survey personnel also helped each respondent to download and install the application, create an account, and run the application on their smartphones.

The recruitment method of our 2017 surveys was improved, as summarized below (Qudratullah and Maruyama 2019a, 2019b):

1. *Incentive:* An incentive of 100 AFGHANI (equivalent to 1.5 USD) was promised to the respondents, and those who successfully completed the two-week survey were entitled to the provision of the reward as phone credit. The purpose of incentive was to improve response rate, data sending rate and survey completion rates. The amount of incentive was set to be larger than the internet cost that was required for running the app for the requested survey period.
2. *Female survey conductors:* In the 2015 survey, we recruited a small sample of female subjects because it was difficult to recruit females by male survey personnel in the traditional society of Afghanistan. Therefore, female survey conductors were included in the survey team in 2017. The purposes of female survey personnel were to increase the number of female participants as well as to assure them regarding their data confidentiality.
3. *Assist for installation the app and creating the account:* In the 2015 survey, we sent the URL of the survey application to the consented respondents individually. They were requested to install the app, create an account and keep the application running for 14 days. Then we obtained 64.0% of data sending rate from that survey (Qudratullah et al. 2019). These activities (installing the app, creating account and running the app) might incur burden on some respondents. Therefore, in the 2017 survey, during the recruitment process, the respondents were assisted with downloading and installing the application, creating the account, and running the application on their smartphones. The purposes of this improvement were to decrease the survey burden on respondents as well as to improve the data sending rate of the surveys.

As presented in Table 1, the respondents were initially categorized as consenting and non-consenting individuals. The consenting respondents were further categorized into two groups: those who sent the data, and those who did not attempt to send their travel information. Additionally, the respondents who began sending data were further grouped into two categories: those who successfully completed two weeks of the survey, and those who stopped sending data before the completion of the survey period.

The response rate (RR) of the survey is the ratio of the number of consenting respondents to the number of recruits.

RR= (Number of consenting respondents)/(Number of recruited individuals)

The response rate in our 2015 survey was 37.5%, whereas it was 62.8% and 39.9% for the 2017 surveys in Kabul and Khost, respectively (Table 1).

The data sending rate (DSR) is the ratio of the number of respondents who start sending data to the number of consenting respondents.

DSR= (Number of respondents who start sending data)/(Number of consenting respondents)

The data sending rate was 64.0% in the case of the 2015 survey in Kabul, whereas in the 2017 surveys, it was 81.4% for Kabul and 75.9% for Khost (Table 1).

The respondents in all three surveys were requested to send their two-week travel data. Therefore, the survey completion rate (SCR) is derived from the ratio of the number of respondents who send data for 14 days to the number of respondents who start sending the data.

SCR= (Number of respondents who successfully complete the survey)/ (Number of respondents who send data)

The survey completion rate of the 2015 survey in Kabul was 43.8%, and for the 2017 survey it was 38.6% for Kabul and 51.5% for Khost (Table 1).

To compare the data sending rate and survey completion rate of different surveys, we conducted a statistical (chi-square) test and arranged the results in terms of the different attributes of the respondents.

Table 2. Comparison of data sending rate of three surveys

	DS Choice Y=yes, N=no	2015 KBL	2017 KBL	2017 KST	2015-2017 (KBL)		KBL-KST (2017)	
		n	n	n	χ^2	P-value	χ^2	P-value
Total	Y	48	70	66				
	N	27	16	21	6.19	.012*	1.161	.281
Male	Y	38	53	53				
	N	11	9	12	1.16	.280	.35	.549
Female	Y	10	17	13				
	N	16	7	9	5.26	.022*	.69	.404
Employed	Y	42	47	35				
	N	16	7	10	3.66	.055	1.47	.224
Unemployed	Y	6	23	31				
	N	11	9	11	6.15	.013*	.034	.853
Age<30	Y	32	39	40				
	N	14	6	15	3.87	.049*	2.89	.089
Age>31	Y	16	31	26				
	N	13	10	6	3.21	.073	.334	.563

Note: DS=Data sending, KBL=Kabul, KST=Khost

*Significant at 5%

3. Result

3.1. Data sending rate

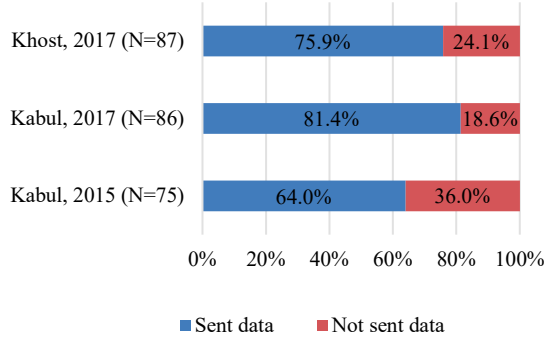
The overall data sending rate of all three surveys are presented in Figure 1 (a). To compare the data sending rate of each survey, we conducted a statistical (chi-square) test, and a statistically significant difference has been confirmed between the 2015 and 2017 surveys in Kabul city (p=.012<.05), as presented in Table 2. From this result, it can be concluded that the data sending rate for the 2017 survey for Kabul significantly increased, when compared with the 2015 survey. Additionally, the results of the data sending rate comparison of the 2017 surveys in Kabul and Khost reveal no statistically significant difference (Table 2). From this result we can conjecture that the same survey recruitment method can have a similar result in local and capital cities, with respect to the data sending rate.

Moreover, we compared the data sending rate of each survey in terms of gender, as shown in Figure 1 (b). The comparison results confirmed no statistically significant difference between the male respondents of the 2017 and 2015 surveys in Kabul city. Similarly, the data sending rate difference between male respondents in the Khost and Kabul surveys in 2017 is not statistically significant. In the case of females, as presented in Table 2, the data sending rate difference between the 2015 and 2017 surveys in Kabul is statistically significant (p=.022<.05). From this result, it can be concluded that the female data sending rate in the 2017 survey in Kabul was significantly increased. However, this difference is not statistically significant with respect to female respondents in the 2017 surveys for Kabul and Khost (Table 2).

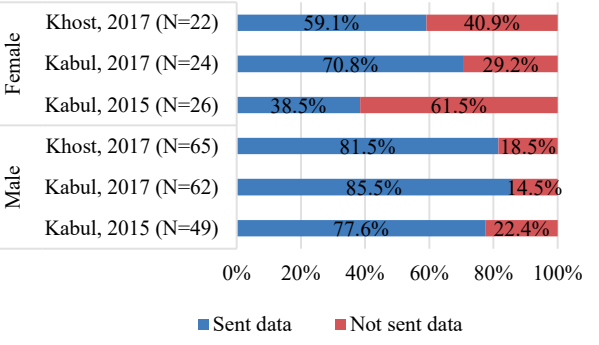
Figure 1 (c) presents the data sending rate in terms of employment information. We have compared the rate of employed respondents in the 2015 and 2017 surveys in Kabul, and that of the 2017 surveys for Kabul and Khost. The

results reveal that the differences are not statistically significant in both cases, as presented in Table 2. In the case of unemployed respondents, a statistically significant difference has been confirmed between the 2017 and 2015 surveys in Kabul ($p=.013<.05$), as noted in Table 2. From these results, it can be concluded that unemployed respondents were more likely to send their data after the recruitment method was improved in the 2017 survey.

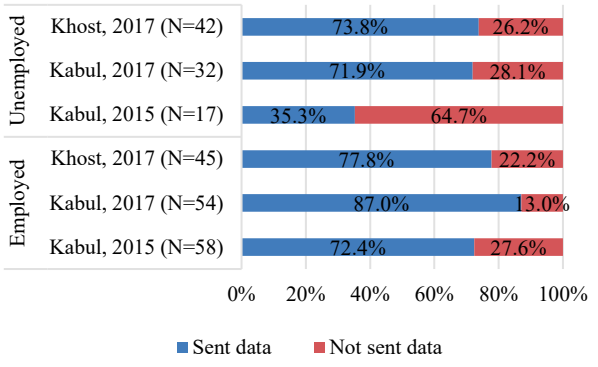
We have also considered the data sending rate with respect to age in all three surveys. As depicted in Figure 1 (d), the data sending rates of both younger and elder respondents are improved in our 2017 surveys. The results reveal that there is a statistically significant difference of the data sending rate of younger (under 30 years of age) respondents between the 2015 and 2017 surveys in Kabul city ($p=.049<.05$), as presented in Table 2. Considering this result, it can be concluded that the data sending rate of respondents under 30 years of age significantly increased after the improvements made to the survey recruitment method in 2017. In the case of older (over 31 years of age) respondents, the results revealed that the differences between the 2017 and 2015 surveys in Kabul, and the 2017 surveys in Kabul and Khost are not statistically significant, as presented in Table 2.



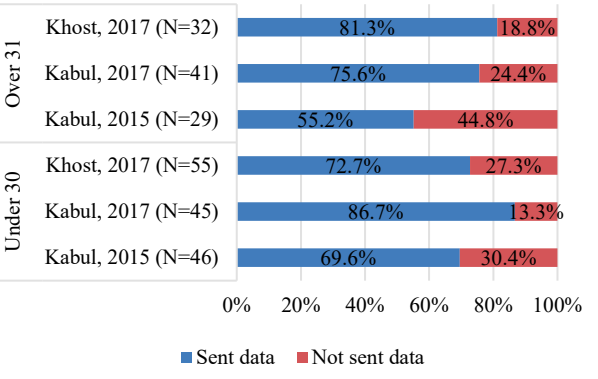
(a) Entire sample



(b) Gender



(c) Occupation



(d) Age

Figure 1. Comparison of the data sending rate of all three surveys

Table 3. Comparison of the survey completion rate of all three surveys

	SC Choice Y=yes, N=no	2015 KBL	2017 KBL	2017 KST	2015-2017 (KBL)		KBL-KST (2017)	
		n	n	n	χ^2	P-value	χ^2	P-value
Total	Y	21	27	34				
	N	27	43	32	.31	.574	2.30	.129
Male	Y	16	22	29				
	N	22	31	24	.003	.955	1.85	.173
Female	Y	5	5	5				
	N	5	12	8	1.14	.285	.27	.602
Employed	Y	19	18	19				
	N	23	29	16	.439	.507	2.07	.150
Unemployed	Y	2	16	15				
	N	4	23	16	.128	.720	.379	.538
Age<30	Y	16	16	17				
	N	16	23	23	.571	.449	.018	.894
Age>31	Y	5	12	17				
	N	11	19	9	.25	.614	5.49	.019*

Note: SC=Survey completion, KBL=Kabul, and KST=Khost

*Significant at 5%

3.2. Survey completion rate

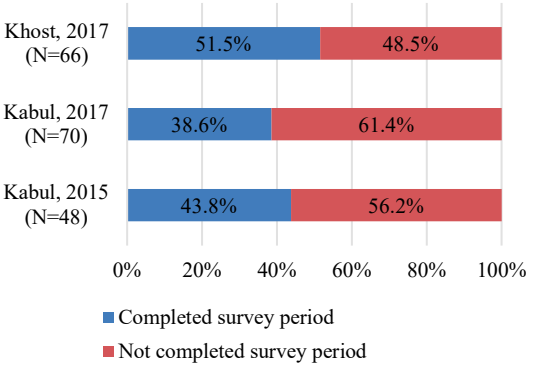
Figure 2 (a) presents the completion rates of entire samples of all three surveys. The completion rate of the 2015 survey in Kabul is 43.8%, whereas for the 2017 surveys, the rates are 38.6% and 52.1% for Kabul and Khost, respectively. We compared the completion rates of the 2015 and 2017 surveys of Kabul city, and the result reveals no statistically significant difference (Table 3). From this, it can be concluded that the improvements of the 2017 survey recruitment method were not significantly effective to enhance the survey completion rate. In addition, we also compared the completion rates of the 2017 surveys in Khost and Kabul. The difference was not statistically significant (Table 3).

Furthermore, we considered the rates with respect to each gender. As shown in Figure 2(b), the completion rate of male respondents in the 2017 surveys did not increase significantly, when compared with that of the 2015 survey. The survey completion rate of male respondents in the 2015 and 2017 surveys in Kabul city are compared, and no statistically significant difference has been confirmed (Table 3). In addition, no statistically significant differences were confirmed between the male respondents of the 2017 surveys in Kabul and Khost (Table 3). Similarly, in the case of the female completion rate, no statistically significant differences were confirmed between the 2015 and 2017 surveys in Kabul, and the 2017 surveys in Kabul and Khost (Table 3).

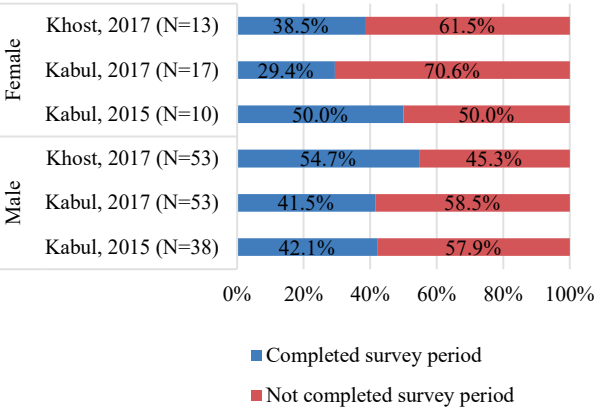
The survey completion rates with respect to employment were also investigated, as shown in Figure 2 (c). The comparison results revealed no statistically significant differences of the survey completion rates between the 2015 and 2017 surveys in Kabul, and the 2017 surveys in Kabul and Khost, with respect to employed and unemployed respondents (Table 3).

Figure 2 (d) presents the survey completion rate with respect to age. The comparison results revealed that there are no statistically significant differences between the survey completion rates of younger respondents in the 2015 and

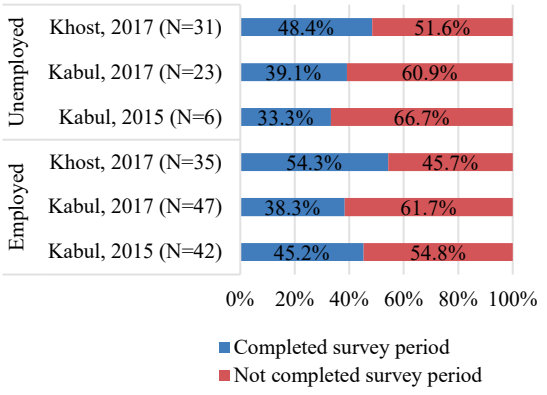
2017 surveys of Kabul, and the 2017 surveys of Kabul and Khost (Table 3). In the case of respondents over 31 years of age, the survey completion rate difference between the 2017 surveys in Khost and Kabul is statistically significant (p=.019<.05), as presented in Table 3. However, the difference between the 2015 and 2017 surveys in Kabul is not statistically significant.



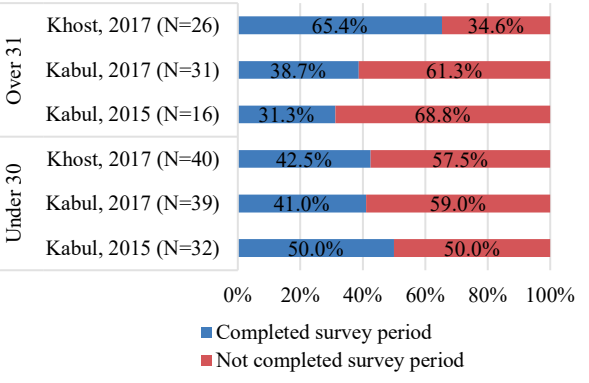
(a) Entire sample



(b) Gender



(c) Occupation



(d) Age

Figure 2. Survey completion rate comparison of all three surveys

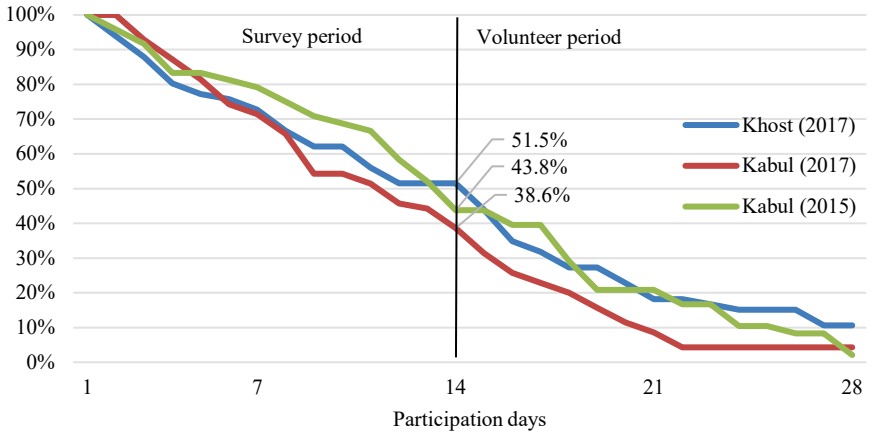


Figure 3. Decline in respondents' participation

The withdrawal of respondents' participation in all three surveys is depicted in Figure 3. The respondents were requested to send their data for two weeks. Therefore, the participation period of first 14 days is the official survey period. Then the completion rates are 51.5%, 43.8%, and 36.6% for Khost survey in 2017, Kabul surveys in 2015 and 2017 respectively. Some respondents participated in the survey for more than 14 days. Hence, the participation period after the first 14 days is defined as survey volunteer period.

In order to investigate further the trends in Figure 3, we applied duration modeling (Klein and Moeschberger 2003) for the data of survey participation days. The duration modeling is useful to investigate the comprehensive effect of attributes on overall survey participation behavior. The analyses of the survey completion rates in Figure 2 and Table 3 were limited because it examined the situation only in 14th day and revealed the effect of attributes independently. The duration modeling can describe phenomena in the whole participation days considering multiple attributes. We tried four distributions for the duration model; exponential distribution, Weibull distribution, log-normal distribution, and log-logistic distribution. We finally use Weibull distribution because it gave the highest log likelihood. The estimation results are shown in Table 4. The positive estimates denote the willingness of respondents to stay longer in the survey. The result indicates that long-time smartphone-owners tend to stay in the survey longer than short-time smartphone-owners. Similarly, the respondents in Khost survey are more likely to stay longer than the respondents in 2015 and 2017 Kabul surveys. In addition, the employed respondents also tend to stay longer in the survey period, when compared with unemployed respondents.

Table 4. Duration model of participation behaviour

Variable descriptions	Estimates	t-value
Intercept	2.211	11.31**
Smartphone owning history	0.178	4.48**
Age	-0.008	-1.61
Male	0.126	1.22
Khost survey	0.186	2.00*
Employed	0.208	2.12*
Scale	0.595	-8.91**
N		184
Distribution		Weibull
Log likelihood		-643.2

*Significant at 5%. ** Significant at 1%

4. Discussion

The findings of our previous study revealed that individuals were significantly motivated by the survey recruitment improvements to participate in smartphone-based travel surveys. For example, the presence of incentives improved the male response rate, whereas the female response rate was improved by the presence of female survey conductors (Qudratullah and Maruyama. 2019b). In the present study, we investigated the effects of the improvements made to the survey recruitment method on the data sending rate and completion rate of smartphone-based travel surveys conducted in Afghanistan. In addition, we compared the data sending rates and survey completion rates of the 2017 surveys in Khost and Kabul. In this section, the dominant factors affecting the data sending rate and survey completion rate of our smartphone-based travel surveys are discussed.

4.1. Data sending rate

The improvements made to the survey recruitments in 2017 (e.g., offering incentives, helping respondents to install and run the application, assigning female survey personnel) seem to have motivated respondents to increase their data sending rate.

The same survey recruitment method was used for the 2017 surveys in Khost and Kabul. The no statistically significant differences in the data sending rates between the 2017 surveys in Kabul and Khost revealed that the same survey recruitment method could have similar results with respect to the data sending rate between rural and urban respondents. The similar results from the rural respondents of Khost and the urban respondents of Kabul are possibly due to the well-organized survey recruitments method that equally motivated the respondents of both the rural and urban areas to send their travel data.

With respect to gender, the male data sending rate did not significantly increase in the 2017 surveys. However, the female data sending rate was greatly increased in the 2017 surveys (see Table 2). In the 2015, the survey team was consisted of male personnel only. Then the female recruits might feel uncomforted for the no female survey conductors. In the other words, female respondents might concern with respect to the protection of their data confidentiality, as well as the disclosure of their images and videos in their devices. Then these improvements of the female data sending rate are due to the assignment of female survey conductors for the 2017 surveys. Given that females in traditional communities are more cautious with respect to the disclosure of their personal images and videos, female respondents were ensured by the female survey personnel of the protection of their privacy, and their data confidentiality. In one of our previous studies, we found that females' privacy concern is one of the dominant barriers against their participation in smartphone-based travel surveys (Qudratullah and Maruyama 2019a).

The statistical comparison of the data sending rates between employed respondents of the 2015 and 2017 surveys in Kabul revealed no statistically significant differences. However, this difference is significant in the case of unemployed respondents (see Table 2). We speculate that the possible reason for this significant difference could be as follow: Unemployed respondents may be less educated. Hence, installing the app, creating the account, and running the app could be challenging to them. Because the program for installation the app, creating the account and running the app was provided in English (the app is in English). Therefore, the help provided by the survey conductors with the installation the app, creating the account and running of the application in the 2017 surveys could be the reason for the improvements appeared in the data sending rate of unemployed respondents.

The data sending rate of younger respondents significantly increased in the 2017 survey in Kabul (see Table 2). This result could be due to the effect of rewards, as the majority of younger respondents may be unemployed (e.g., schooling age). Therefore, the same rewards may be of greater value to younger respondents, when compared with older respondents.

4.2. Survey completion rate

The comparison results of the survey completion rate between the 2017 surveys in Khost and Kabul revealed that the older respondents from the local city of Khost are more likely to complete the survey period, when compared with their counterparts in Kabul (see Table 3). It can be conjectured from this significant difference that these respondents

from Khost are more concerned with receiving the reward. The same rewards may therefore have been more valuable to some local individuals than city residents. A survey conducted by Afghanistan Central Statistics Organization (2017) reported that overall employment rate in Kabul (32.7%) is higher than that rate in the city of Khost (27.8%). However, we found no income data in order to make comparison between Kabul and Khost populations (Afghanistan Central Statistics Organization, 2017). In addition, older respondents as heads of families may obligated to provide financial support to the family members. Thus, the older respondents of Khost may attempt to complete the survey to receive the reward.

In addition, the results of duration model showed that the respondents who owned smartphone for long-time are tend to participate longer than those who owned the device for shorter period of time. The effects of smartphone history on the retention of respondents for longer time could be due to the greater experience with smartphone use of those who owned smartphone for long-time. Similarly, the respondents in Khost survey are more likely to stay longer in the survey compare to the respondents of other two surveys. We speculate that respondents from Khost survey may be tried to get the reward. Because the same rewards may be more valuable to the local individuals than city residents (as stated earlier, the employment rate in Khost city is lower than Kabul city). The employed respondents were also more likely to stay longer in the survey compare to those who have no jobs. These effects could be due to the higher chance of charging the device battery in the working place for employed respondents, while the unemployed respondents may have limited chance of charging the device battery.

4.3. Comparison with Existing Studies

Here we compare our results in Afghanistan with existing studies in other countries. Safi et al. (2015) investigated the data sending rate of a smartphone-based travel survey conducted in New Zealand as a case study in developed countries. They reported that out of 186 recruited individuals, 77 participants installed the application, 73 participants uploaded at least one travel day, and 65 participants completed the survey successfully. By our definition, their response rate is 41.4% (=77/186), the data sending rate is 94.8% (=73/77), and the survey completion rate is 89.0% (=65/73). These rates are higher than our rates. Note that the requested survey days of Safi et al. (2015) is three days, which is much shorter than our 14 days.

As another case in developed countries, Zhao et al. (2015) reported on a smartphone-based travel survey conducted in 2012/2013 in Singapore. They recruited 1,541 users, and of them, 793 participants completed the survey. That rate of 51.5% (=793/1,541) can be interpreted as the survey completion rate or the completion rate multiplied by the data response rate by our definition. Either way, those rates are higher than our rates.

In the case of developing countries, Zegras et al. (2018) reported on a smartphone-based travel survey conducted in Tanzania. They report that out of 581 consenting respondents, 482 participants provided at least one verified trip/stop, and 329 participants sent and verified at least one travel day. The data sending rate for that survey is 83.0% (=482/581) or 56.6% (=329/581). A comparison of these rates with our data rates (64.0% in the 2015 survey in Kabul, 81.4% in the 2017 survey in Kabul, and 75.9% in the 2017 survey in Khost) is not a direct one, but we suggest the values in two developing countries, Afghanistan and Tanzania, are not very different.

At this time, it would be inappropriate to make a decisive conclusion from these comparisons because the survey settings (e.g., survey periods, applications, and rewards) are different, but these comparisons may indicate that the data sending rates and survey completion rates of smartphone-based travel surveys in developing countries is lower than those in developed countries. Please note that data sending and survey completion can be defined in several ways in smartphone-based surveys, and the comparisons using same definition will give us further insights in future work.

5. Conclusion

In this study, we investigated the data sending rate and survey completion rate of three smartphone-based travel surveys conducted in two Afghanistan cities. The first survey was conducted in 2015 in the capital city of Kabul. In 2017, we improved the survey recruitment method and conducted two more smartphone-based travel surveys in Kabul and the local city of Khost. The improvements made to the 2017 surveys in are as follows:

1. An incentive of 100 AFGHANI (equivalent to 1.5 USD) was promised to the respondents, and those who successfully completed the two-week survey were entitled to have the rewards provided as phone credit.
2. Female survey conductors were included in the 2017 survey team.
3. The respondents were assisted with downloading and installing the application, the creation of the account, and the running of the application on their smartphones.

We then compared the data sending rate and survey completion rate of the three smartphone-based travel surveys. From the comparisons, the findings below were obtained:

4. Survey improvements increased the overall data sending rate.
5. The female data sending rate significantly improved after the improvements made to the survey.
6. The data sending rate of unemployed respondents was significantly increased by the recruitment method.
7. The survey completion rate did not increase after the improvements made to the survey.
8. The differences between the data sending rates and survey completion rates of the Kabul survey and Khost survey were minimal.
9. The long-time smartphone users, respondents in local city and employed respondents were tend to stay longer in the survey.

Considering our previous studies, and from these findings, we reached the following conclusions:

10. Survey recruitment method improvements (e.g., offering incentives, assigning female survey conductors) can initially improve the response rate of smartphone-based travel surveys.
11. Improving the survey recruitment method can positively affect the data sending rate of smartphone-based travel surveys.
12. The survey completion rate of smartphone-based travel surveys cannot be greatly increased by improvements to the recruitment method.
13. If the same survey recruitment methods are applied, similar data sending rates and survey completion rates can be obtained from local and urban cities.

Along with these contributions, however, our study has the following issues for future work. First, in a questionnaire survey, random sampling is also important, as is a large sample size. This study focused on strategies to increase the number of survey participants, data senders, and survey completers, but it may lead to non-random sampling. For example, our results revealed that long-time smartphone users and employed respondents tended to participate and complete the survey, which may indicate that our sample-increasing strategies might increase them only for those participants, and may lead to non-random sampling. The examinations of this issue are outside the scope of this study, and future work is needed.

Second, our smartphone-based travel surveys would be the first trials in Afghanistan, and due to limited human resources, we collected a limited sample size for all three surveys. Even with this small sample, we made several important findings using statistical analysis, but we must increase the sample size to make these findings more reliable. This is another issue for future work.

Third, our 2017 survey made three improvements: (1) incentive provision, (2) female survey conductors to recruit females, and (3) assistance in the installation and running of the application. These effects were confounded in our study. To distinguish the effect, we need an experimental design or an additional questionnaire to investigate these three factors. If we increase the sample size, these investigations will be possible.

Finally, in 2017, along with the smartphone-based travel surveys, we conducted a supplementary paper-based travel survey using the same respondents. Using the smartphone-based and paper-based travel survey data to compare the recorded trips and travel time is another objective of our future work.

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