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Methodological Challenges for Measuring Behavioral Changes in a Longitudinal Travel Survey Under Pandemic Conditions

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Abstract

The outbreak of the COVID-19 pandemic has had an enormous impact on everyday life. In an attempt to stop the virus spread, unprecedented containment measures are being taken worldwide. These preventive measures are consequently affecting everyone's life and how we move. Equally remarkable is the speed at which these observed and massive changes occur and the lack of statistical evidence. In the annual cycle, the German Mobility Panel (MOP) launched an additional questionnaire for the general population, containing approximately 4,000 respondents. This paper provides insights into the MOP data quality issues and changes in daily travel under pandemic conditions.

1. Introduction

With the Coronavirus (COVID-19) outbreak and its classification as a pandemic by the World Health Organization in 2020 (WHO, 2021), life in Germany and around the world has changed. Measures were enacted to stop the virus spread that significantly impacted everyday life. At the same time, reliable statistical findings during the pandemic were unavailable as quickly as needed. In the remarkable speed at which changes occur and the lack of statistical evidence accompanying them, data collection during the pandemic faces several challenges. First, fast data collection is needed to provide a data baseline on the status quo. Second, the data needs to be reliable so that researchers can rely on their analysis and policymakers can make fruitful and fast decisions.

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One shortcoming of COVID-19-related research is that most surveys are based on non-probability samples, which do not accurately reflect the general population (Blom et al., 2020). Thus, it is not permissible to generalize the results of studies on a non-probabilistic sample to the entire population. Furthermore, long-standing panels are more appropriate than cross-sectional surveys to study intrapersonal behavioral changes. By the outbreak of the COVID-19 pandemic, the German Mobility Panel (MOP) was in a great position to serve with a well-established probability sample and a survey design that was elaborated over decades. The annual rhythm of the survey allows for measurements before and during the COVID-19 pandemic. For the MOP 2020 wave, it was decided to add a questionnaire to the survey documents in order to collect further information about changes in travel behavior under pandemic conditions. The additional questionnaire (AQ) intends to understand COVID-19-related changes in everyday life and thus to better understand changes in daily travel.

This study addresses two research questions: First, the innovation of the study during the pandemic will be evaluated. Second, it will be investigated how the additional questionnaire in 2020 can contribute to a better understanding of the changes in travel behavior.

The study is structured as follows: First, section 3 presents the MOP data, including the AQ and discusses special features in the 2020 survey period. Section 3.1 describes experiences from the fieldwork 2020. Section 3.2 focuses on the sociodemographic characteristics of dropouts and response modes of the questionnaires. Section 3.3 uses the example of shopping activities to show how the additional questionnaire helps to better understand travel behavior during the pandemic. Section 5 summarizes and concludes the findings.

2. Literature

The presented literature review reveals literature surveys about travel behavior data collection during the COVID-19 pandemic. In the following, we provide a brief overview of travel surveys, addressing both study methodology and findings. During the first two years of the COVID-19 pandemic, many travel surveys were conducted to study changes in travel behavior and daily routines. We focus on european travel behavior surveys. Two types of data collection can be distinguished: (One-time) Ad hoc surveys and surveys that collect data regularly.

First, it should be noted that reported behavior is subject to variability (Kitamura et al., 2006; Mallig and Vortisch, 2017). However, it can be observed that due to the strong exogenous influence of the preventive measures to stop the virus spread, travel behavior has changed. However, classifying the level of this variability is challenging.

In a survey by Eisenmann et al. (2021), 1,000 individuals were recruited for an online survey (access panel). Individuals were asked to report on mode use and well-being in the transport system at regular intervals in 2020 (panel design). The study aims to capture changes in the status quo during the pandemic. However, baseline travel before the pandemic can only be asked retrospectively. The results of the study show that public transport became less important during the particularly restricted closure period, while private transport, especially cars, became more important.

Another approach is the MOBIS:COVID-19 study. It is a continuation of the MOBIS study in Switzerland. In the beginning of the pandemic, a new objective was defined for the survey. The aim of the study in the first COVID-19 wave was to understand how the pandemic situation affects mobility and daily life. Online questionnaires and GPS tracking were used for data collection (Molloy et al., 2021). This allows for a long observation period and reduces the response burden. The survey results show that the average daily mileage was reduced by around 60%, and for public transport the reduction was over 90%. The share of bicycles in traffic increased significantly.

Participants in the Netherlands Mobility Panel (MPN) were surveyed during the first lockdown in 2020 on changes in travel behavior. The MPN has been in operation since 2013. It is an online access panel that allows participants to be observed in a flexible time frame. The spring 2020 survey departed from the annual rythm (Haas et al., 2020). The results of the 2020 survey in the first lockdown show that about 80% of people reduced their outdoor activities. 44% of workers started or increased the number of hours they work from home, and 30% have more remote sessions. In addition, the number of trips and distance traveled are down 55% and 68%, respectively, compared to the fall 2019. Furthermore, changes in outdoor activities appear to be temporary: Over 90% of those who have currently reduced their outdoor activities do not expect to continue this behavior in the future according to COVID-19. However, 27% of home-based workers expect to work from home more often in the future. In addition, 20% of people expect to bike and walk more in the future, and 20% expect to fly less.

3. Data

This section provides an overview of the MOP, summarizes the survey mode adaptations made for the 2020 survey, and introduces the sample used for the analysis.

3.1. German Mobility Panel

The data used for this study originates from the MOP. It is a German national household travel survey that has been conducted yearly since 1994. The survey is carried out on behalf of and funded by the German Federal Ministry for Digital and Transport. The market research firm Kantar is responsible for the fieldwork (i.e., recruitment and data collection) and the Institute for Transport Studies of the Karlsruhe Institute of Technology is in charge of the design and scientific supervision of the survey (Ecke et al., 2021; Jödden and Führer, 2021; Zumkeller and Chlond, 2009). Since 1994, the MOP has seen only minor survey design adaptions (Chlond et al., 2015; Eisenmann et al., 2018a, 2018b).

The sample is controlled by spatial categories, household type, and car ownership on the household level and gender and age on the individual level. The sample size is 1,500-2,000 households containing about 4,000 persons. Participants are asked to report their everyday travel over the course of seven days for three consecutive years. Each year, a portion of the households drops out and is replaced with new households. Thus, the data collection period is in the fall and the survey weeks are chosen to avoid school and bank holidays.

The survey design of the MOP has excellent advantages for measuring behavioral changes during the COVID-19 pandemic. First, the survey has been tested for decades and many studies have investigated the survey design in the non-pandemic state. Second, no individuals need to be recruited exclusively because the survey is in operation and the rotating panel approach allows for a continuous refreshment of the sample. Another advantage of the survey design is that individuals can be observed over three consecutive years. Thus, changes at the inter- and intra-individual levels can be identified and compared.

Households in the MOP were surveyed in the 2020 wave in two periods. The 2018 and 2019 cohorts, who participated in the survey for the second or third time, respectively, were surveyed in the fall of 2020. During this period, comparatively few COVID-19 containment measures were declared. The 2020 cohort was surveyed in January and February 2021. During this period, a lockdown was enacted in Germany, which had far-reaching effects on public life and restricted mobility to essentials (Bauer and Weber, 2021). In contrast to fall 2020, COVID-19 vaccines were already available in January/February 2021. But during the survey period, vaccines were only accessible to a comparatively small number of people.

3.2. Survey mode adaption in the 2020 survey

Each household recruited for participation gets a household questionnaire in the basic survey design. Furthermore, trip diaries are provided to all persons above ten years willing to participate. The household questionnaire provides information about the participants' sociodemographics on the household and individual levels. Further, information about car and bicycle availabilities and the possession of season tickets and access quality to public transport are collected. All participants are asked to provide a trip diary containing information about all their trips during seven consecutive days (one week), i.e., distances traveled, transport modes, trip purposes, and start and end times.

The basic survey documents lack some depth at parts in explaining behavioral changes. To this aim, an additional questionnaire (AQ) was added to the 2020 survey documents. The survey adaption in 2020 aimed to better link COVID-19-related changes in everyday live on the individual level to changes in travel behavior. Therefore, questions about general behavioral changes were asked in the AQ. The AQ was designed according to the basic survey documents. The challenge of the AQ design was to balance the response burden with the motivation and incentive of the respondents. The AQ is displayed in Figure 1. It was provided for CAWI and PAPI and addressed four different topics.

Household level: First, changes in vehicle ownership (e.g. car, bicycles) and mobility options (e.g. carsharing membership, season tickets) are asked. Because of COVID-19 infection fear, people avoided public transport during

the survey period. Due to increased telecommuting, some people canceled their season tickets or purchased/removed a car. To this aim, in-depth questions were asked to better understand the structure of acquisition or purchase of means of transport because the basic survey documents only collect information on ownership of means of transport.

Furthermore, additional questions about shopping habits, especially online shopping, were asked. The questions about shopping behavior are designed according to the "travel skeleton" approach (Behren et al., 2018). The "typical" travel behavior refers to the rhythm of the repetition of activities. Because travel behavior changed during the pandemic, surveying shopping behavior in the structural context across several weeks is helpful.

Individual level: Additional questions about (initial) changes in leisure activities focusing on the usage of digital services (e.g. streaming services, video conferencing) were asked. For part-time or full-time employees, various questions about changes in the working environment were asked. It was assumed that changes in the world of work, in particular, significantly impact everyday travel behavior. The aim of the basic survey documents is that the questions are designed to address all people to the same extent. Since the questions about the world of work address a subset of the sample (employees), the questions were placed at the end.
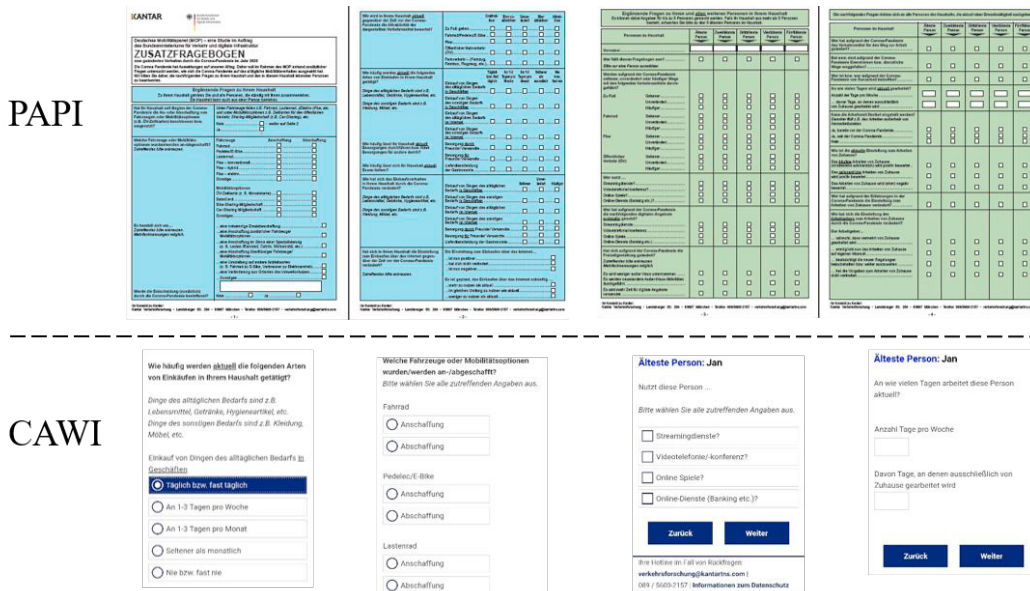

Figure 1. Additional questionnaire of the 2020 survey – CAWI and PAPI documents are designed according to the basic documents

3.3. Data preparation

The data preparation includes data linkage as well as data aggregation. The additional information from the AQ is stored in separate data sets at the household and person level. By means of an ID at the household and person level, the information can be uniquely assigned to a person or household. This unique ID remains unchanged over the reporting period. This means that the ID can identify individuals in successive years. The AQ information is linked to the household or person level based on the identification variables for the analysis.

Trip information is only available for persons who have submitted a trip diary. The sociodemographic information of persons who did not submit a trip diary is in a separate file. Also, for persons without a trip diary, the data from the AQ are linked to the sociodemographic information of these people.

Last, households that participated in the survey in both years are identified for the analysis of section 4.3. The identification is based on the ID from the household level. 1,055 households participated in the survey in 2019 and 2020.

3.4. Study sample

This study uses various data from the MOP of 2018, 2019, and 2020. The sample composition of people with trip diaries for 2019 and 2020 are shown in Table 1. The results are weighted by area status, the number of cars, and household size, age, and gender. In 2019, 3,612 people and in 2020 3,889 people participated in the survey. In 2020, 3,416 people reported their mobility in a trip diary. Section 3.3 analyzes only households in the 2018 and 2019 cohorts that participated in 2019 and 2020 (n=1,055).

4. Experiences and outcomes

This section presents the experience of the AQ, analyzes aspects of data quality and provides insights into the extended potentials for the analysis.

4.1. Surveying under pandemic conditions – experiences from the fieldwork

First, it needs to be mentioned that the participants were not urged to complete the AQ. Even without the AQ, the information from the basic questionnaire is valid. 1,940 out of the 1,967 households that participated in the everyday travel survey in 2020, completed the AQ (98.6%). One explanation for the good acceptance of the AQ is that a tangible topicality reference of the questions and a meaningful added value were recognizable for the respondents (face validity).

For a part of the sample, certain AQ questions were irrelevant (e.g. non-employed persons, persons in households without change of mobility tools). This can negatively affect motivation and response quality. However, a measurable negative influence on the willingness to answer was not determined. Overall, no negative reactions to the AQ were reported by participants during the fieldwork.

4.2. Descriptive analysis – sociodemographic characteristics

Attrition between survey waves is a common phenomenon observed in panel surveys. Participants who are expected to report in the next survey wave stop participating. Dropout selectivity depends on the sociodemographic characteristics and has already been described under non-pandemic conditions in the literature (Kitamura and Bovy, 1987). Therefore, we will first investigate whether the dropout selectivity of 2018/2019 differs from 2019/2020.

First, we examine the overall dropout share. To do this, we examine the proportion of people who drop out of the study after the first or second report and do not participate a third time. In 2019, the overall dropout share of the 2017 and 2018 cohorts is 28%, which means that of the individuals who report a second time, 72% of those originally recruited are still there. In 2020, the overall dropout share of the 2018 and 2019 cohorts is 24%, below the 2019 level.

Table 1 displays a differentiation of the dropout composition between the survey waves 2018/2019 and 2019/2020. The dropout share between the 2018 and 2019 surveys is measured under non-pandemic conditions. The 2019/2020 dropout share represents a transition from a non-pandemic to a pandemic survey period. Furthermore, the sample composition for 2019 and 2020 are presented. We also include respondents who did not report a trip diary in the 2020 survey because additional information about changes in everyday travel was also reported in the AQ in 2020 (for the 2018 and 2019 cohorts).

Younger people seem to be less bound in 2019/2020 as they disproportionally drop out of the survey at a higher rate (20.8%). In contrast, older people tend to stay in the MOP. Notably, the dropout share of people with mobility restrictions in 2019/2020 (12.3%) is lower than in 2018/2019 (12.9%). One reason for this might be that in the cover letter for the MOP in 2020, people were more encouraged to participate in the study even if they made very few or no trips. However, a chi-square test failed to show a significant difference between groups ($\chi2$ (2, N = 1,213) , p = .758).

Summing up, it can be concluded that between 2018/2019 and 2019/2020 the same groups tended to drop out at a high rate - young people and people in education. Based on the analysis, no conclusion can be drawn that the self-selection effects are affected by the pandemic circumstances in 2020.

Table 1. Composition of respondents that dropped out between 2018/2019 (non-pandemic conditions, cohorts 2017 and 2018) and 2019/2020 (pandemic conditions in 2020, cohorts 2018 and 2019) and sample compositions of 2019 (cohorts 2017, 2018, 2019) and 2020 (cohorts 2018, 2019, 2020)

[%]	Dropout share 2018/2019	Sample composition 2019	Dropout share 2019/2020	Sample composition 2020
Age:10-25 years	15.1	14.2	20.8	15.2
Age:26-35 years	9.4	7.4	8.7	7.9
Age:36-50 years	20.1	17.3	19.1	18.5
Age:51-60 years	22.2	22.6	21.5	24.2
Age:61-70 years	15.1	21.8	16.5	20.0
Age:70+ years	18.1	16.7	13.5	14.2
Employment status: employed	51.1	50.3	52.7	53.1
Employment status: in education	14.3	13.5	18.5	14.0
Employment status: pensioner	28.1	31.6	24.8	27.4
Employment status: other	6.5	4.6	4.0	5.6
Mobility restrictions: yes	12.9	11.5	12.3	9.1
Mobile phone: yes	77.5	80.1	83.9	83.0
Sample size [n]	*636*	*3,612*	*577*	*3,889*

Since 2013, households can answer the questionnaires online (CAWI) or on paper (PAPI). In 2019, 10 % of households completed the questionnaire and 12% completed the trip diary online (Ecke et al., 2020). Therefore, it is interesting which mode is chosen in times of a pandemic and if we see differences in sociodemographics. Since the AQ was also offered online, we further investigated the acceptance. Table 2 shows the response modes for the household questionnaire, the travel diaries, and the AQ.

First of all, it must be noted that 14.5% of the households fill out the household questionnaire, 13.2% of the persons the trip diary and 13.8% of the households the AQ online. One reason for the growing online response rate for the MOP might be the fear of infection with COVID-19. Still, environmental reasons such as paper division and digitizing data are also possible explanations for the high CAWI response rate. However, most households (71.4%) still return all three paper questionnaires. One reason for the high PAPI response rate is that households with older people are less socialized with digital devices and consequently report in PAPI. Thus, 87.5% of people over 70 years choose PAPI for all three questionnaires.

It is particularly encouraging that only 1.1% of households do not complete the AQ. In particular, persons under 35 years are especially willing to answer the supplementary questionnaire (0.7%). One reason is that the AQ can be completed comparatively quickly. Furthermore, young people are not obliged to answer for themselves - other household members can answer as a proxy. Moreover, 1.5% of people over 70 refuse to complete the AQ. One reason is that the topics may not concern them and they refused to answer. Older people are less likely to acquire or dispose of new means of transport. An increase in PAPI selection with increasing age is evident for all three questionnaires.

Table 2. Descriptive statistics of participation mode in the 2020 wave

Survey document	Household questionnaire		Trip diary			Additional questionnaire			All three documents PAPI
Survey Mode [%]	PAPI	CAWI	PAPI	CAWI	None	PAPI	CAWI	None	
Age:10-25 years	83.8	16.2	64.5	12.5	23.0	83.4	15.9	0.7	63.1
Age:26-35 years	81.8	18.2	67.4	15.0	17.6	81.1	18.2	0.7	64.8
Age:36-50 years	79.7	20.3	70.8	19.9	9.3	79.0	19.8	1.3	69.1
Age:51-60 years	85.9	14.1	78.1	13.8	8.1	85.7	13.3	1.1	77.0
Age:61-70 years	87.2	12.8	80.4	12.2	7.4	87.1	11.7	1.2	79.3
Age:70+ years	94.0	6.0	88.6	4.7	6.7	93.3	5.2	1.5	87.5
Employment status: employed	83.4	16.6	73.9	16.0	10.2	82.9	16.1	1.0	72.2
Employment status: in education	82.5	17.5	66.0	13.2	20.8	82.5	17.1	0.4	64.7
Employment status: pensioner	91.1	8.9	84.9	7.9	7.2	90.6	8.1	1.3	83.8
Employment status: other	86.2	13.8	73.9	13.3	12.8	85.8	11.5	2.8	73.4
Mobility restrictions: yes	89.8	10.2	81.6	8.2	10.2	89.6	9.3	1.1	80.2
Mobile phone: yes	83.5	16.6	73.8	15.1	11.1	83.0	15.8	1.2	72.3
Additional questionnaire completion: yes	86.3	13.7	84.8	13.9	1.4	86.3	13.7	-	84.0
Total	85.5	14.5	75.8	13.2	11.0	85.1	13.8	1.1	71.4
Sample size [n]	*3,326*	*563*	*2,947*	*514*	*428*	*3,310*	*537*	*42*	

4.3. Combining the results of the AQ with the trip diary data – an example of understanding shopping-related travel

This section addresses how the AQ helps to understand shopping-related mobility behavior in the pandemic. To do so, we first present the shopping-related information from the trip diary. Further, we present the shopping-related information based on the AQ and show how the data helps to better understand shopping-related travel changes.

Only households that participated in the MOP in 2019 and 2020 are examined (n=1,055). For these households, statistical measures of the trip diary can be calculated for both years. Thus, changes at the individual level can be identified and quantified. The data of households that participated in the survey for the second or third time were mainly collected in October 2020. At that time, comparatively few measures to reduce physical contact were valid in Germany. Social life returned to normal after the first wave in the spring of 2020 (Bauer and Weber, 2021), but a COVID-19 vaccine was unavailable.

Trips that lead to shopping activities are grouped to *shopping*. This category includes many shopping occasions, such as grocery shopping, buying cigarettes at a cigarette machine, or shopping for furniture at a furniture store. These types of shopping differ significantly in it's duration and frequency: shopping for cigarettes at a cigarette machine takes only a few seconds. It is done several times a week. In contrast, shopping for furniture in a furniture store is a rather one-off activity and is carried out comparatively infrequently. These shopping occasions are summarized as shopping activities in the trip diary.

Table 3 presents descriptive measures of shopping activities based on the trip diary data in 2019 and 2020. In addition, a paired t-test (95 % confidence level) is performed to examine whether the measures differ between years. For the analysis, information from the trip diaries is aggregated at the household level. This step is necessary to

compare the results to the AQ results. As described in section 2.2, information on shopping behavior during the pandemic is asked at the household level.

The results show that the number of shopping trips did not change significantly between 2019 and 2020. However, the total number of trips changed significantly (t=9.87). We see a decrease of 3.7 trips per week and household compared to 2019. Based on this analysis, the reasons for this decrease do not appear to stem from a reduction in shopping trips. Furthermore, we examined whether the number of days with shopping activities changed over the years. The results show a significant decrease (t=2.20) in the number of days with shopping activities. This observation suggests that while households did not necessarily make fewer trips for shopping purposes, they were clustered on a few days per week.

Table 3. Statistical measures and t-test statistics based on information of the trip diaries in 2019 and 2020

Year	2019	2020	
Measure	mean (SD)	mean (SD)	t
Shopping trips/week	5.0 (544.7)	4.9 (531.6)	0.54
trips/week (total)	35.3 (3330.5)	31.6 (3034.1)	9.87*
Days with Shopping	3.2 (235.4)	3.1 (226.5)	2.20*

Note: * p<.001

In the AQ, the frequency of shopping activities is queried for a longer observation period. This extends the temporal horizon of the questionnaire compared to the trip diary, in which the temporal horizon refers to seven days. To compare the results of both measurements (trip diary and AQ), we transform the information from the trip diary for the following analysis. Figure 2 shows how frequently households went shopping in 2019 and 2020. The analysis is based on trip diary data for 2019 and 2020. It can be seen that fewer households went shopping almost daily during the pandemic. It can also be seen from the analysis that 95% of the households went shopping at least once a week in 2019 (96% in 2020). Furthermore, a chi-square test was performed, indicating a significant difference between the years ($\chi2$ (2, N = 3,816), p = .005). However, no information on the type of shopping activities is given. Furthermore, it needs to be mentioned that the information might be incomplete because some trip diaries are missing, especially in households of more than one person.
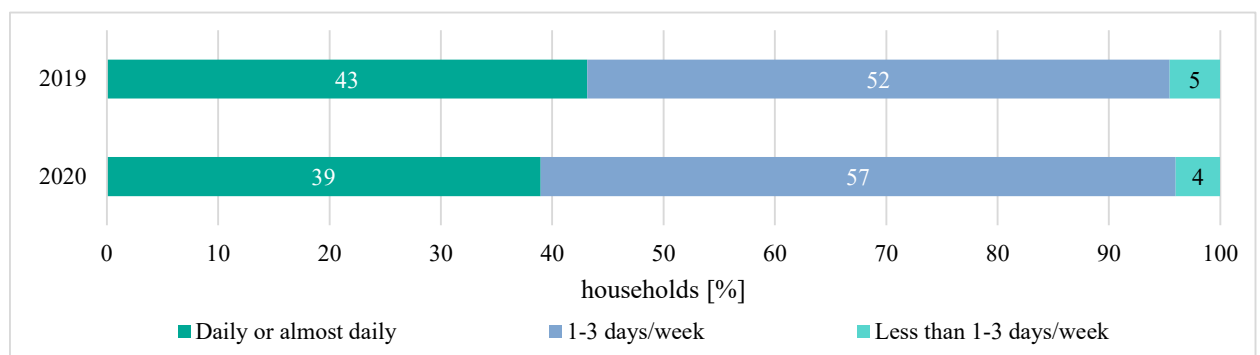

Figure 2. Shopping frequencies of households, information based on trip diary data of 2019 and 2020

Figure 4 displays detailed information on different shopping frequencies, differentiated by the type of goods and locations. The analysis is based on the AQ. The figure shows that 95 % of households buy everyday necessities (e.g. grocery shopping) at least once a week. This result is in line with the results based on the trip diary data (Figure 2). 14 % of households report that they shop for everyday necessities (almost) nearly every day. The results suggest that everyday necessities alone cannot explain shopping behavior.

Figure 4 also shows that 11% of households purchase consumer goods at least once a week. Furthermore, 19 % order everyday necessities on the internet at least once a week; consumer goods are ordered by 38% at least once a

week. 60 % report that they never order everyday necessities on the internet. Only 20% report that they buy stuff for others, while 41% do not have to leave the house to go shopping because other people are shopping for them. Shopping is done primarily for the elderly because they are particularly exposed to contracting severe COVID-19 and shopping through others reduces this risk of infection. Furthermore, it is also noteworthy that one-third of households order food at least once a month.
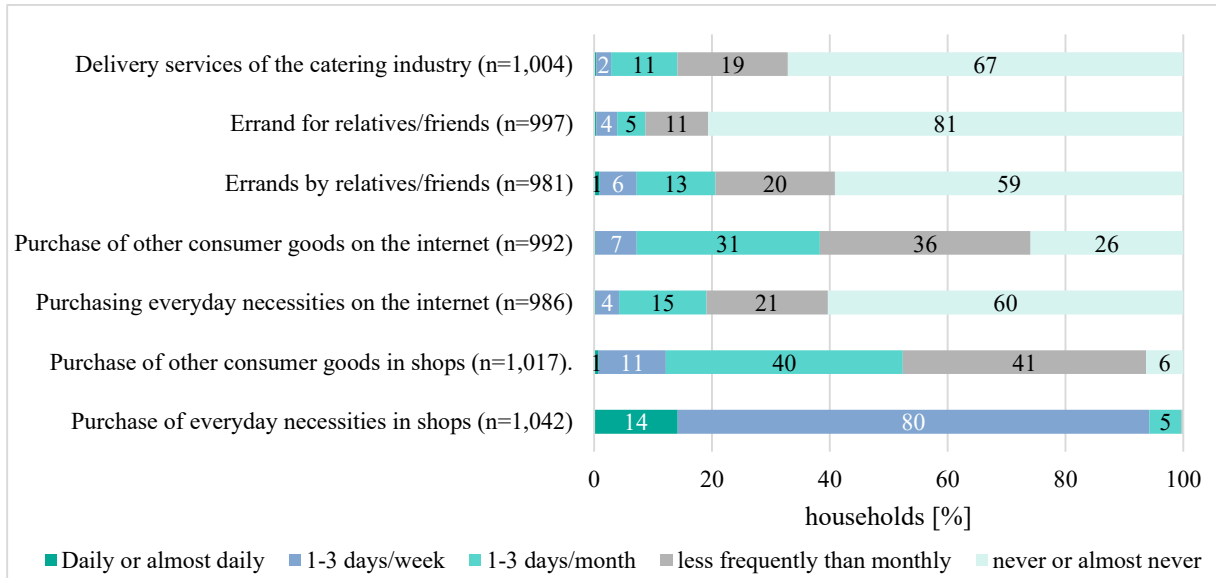

Figure 3 Detailed shopping information of households, based on the AQ in 2020

Since the trip diary does not ask about detailed shopping activities, the AQ also asked about the change in shopping frequency, as displayed in Figure 4. Most respondents report that their shopping behavior has not changed for all categories. Compared to previous years, 23% reported a decrease in grocery shopping. On the one hand, 39 % report a reduction in shopping for consumer goods. On the other hand, 17% of households report increasing online shopping
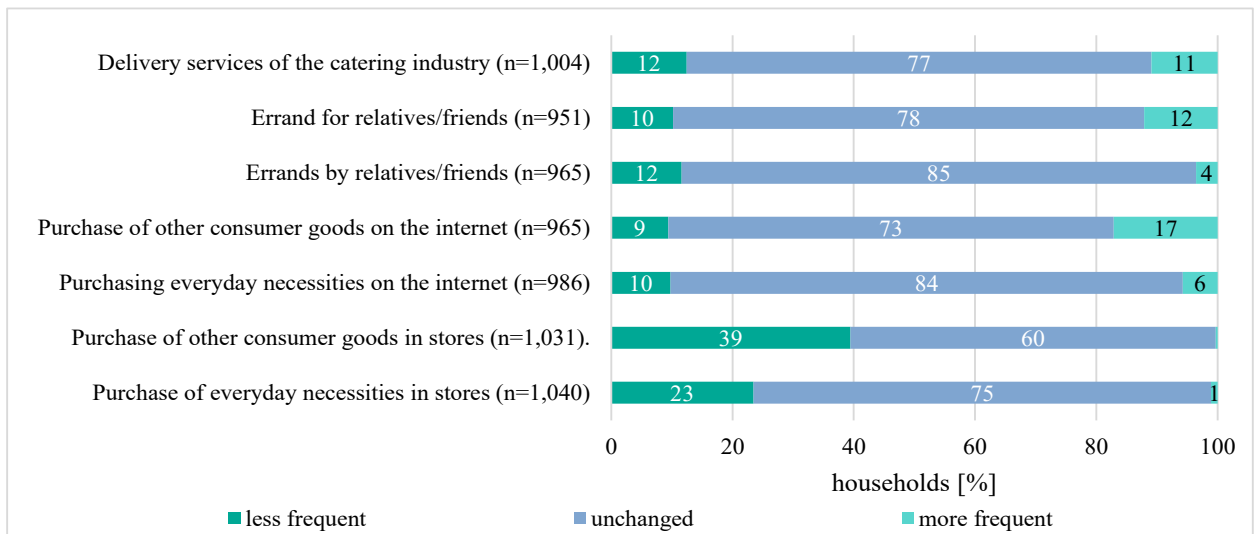

Figure 4. Changes in shopping frequencies, based on the AQ 2020

for consumer goods. 6% of households report doing so for everyday necessities. Everyday necessities are purchased on the internet by only a small group, and COVID-19 did not significantly lead people to do so and maintain this behavior.

5. Limitations of the presented approach

This section discusses the limitations of the AQ. Generally speaking, travel behavior is subject to a specific variability from week to week. Especially in a pandemic, this variability gains speed, as pandemic events are sometimes dynamic and behavior must be adjusted immediately. However, the study cannot explain the dynamics of the pandemic in detail and, thus, the potential that arises from it in the mid- or long-term.

Furthermore, it must be pointed out that the explanations based on the AQ can only be interpreted in aggregates. Moreover, not all people could be motivated to answer the whole questionnaire. The analysis illustrates that some households do not answer online shopping questions. One reason for this is that older people, in particular, do not use online services and consequently do not feel addressed by this question. However, the survey cannot provide an answer as to why the answer was refused.

6. Conclusion

It was a good decision to implement the MOP in the annual rhythm. The results show that the long-term survey design of the MOP is suitable for recording everyday travel during a pandemic. The results also show that implementing an AQ does not necessarily lead to poor response rates in general an, especially in the travel diaries. Therefore, it can be concluded that the participants rated the face validity of the AQ in the context of MOP 2020 very highly. It is shown in the presented study that the pandemic did not lead to a significant change in non-random attrition, meaning that the dropout selectivity does not substantially differ from non-pandemic years. In addition, it was revealed that many people filled out the questionnaires online to minimize close contact to others. It remains open, if these people continue by CAWI the next year(s). In the past, it was demonstrated by Eisenman et al. that many participants chose the CAWI option in the first year of the report but switched back to PAPI in the following wave (Eisenmann et al., 2018b).

Furthermore, based on the example of shopping-related travel, the study demonstrates how the additional information of the AQ helps to better understand changes in shopping during the pandemic. Overall, the results indicate that shopping, especially for everyday necessities, is an activity that is highly consistent even in times of a pandemic. Only a small proportion of households have changed their shopping behavior - most households show high stability. The analyses based on the AQ and the trip diary are in line, which means that valid results were collected with both questionnaires. However, the detailed differentiation of whether something is done daily or a few times a week leads to different results with the questionnaires. One reason is that the aggregated information based on the trip diaries can only be calculated from people with a trip diary. This distorts the results at the household level if trip diaries of individual persons are missing. Another reason is that the week's randomness leads to discrepancies between the trip diary and the mobility skeleton approach on the individual level. This observation was also demonstrated by Sascha von Behren (2021).

Summing up, this work demonstrates that the participating households of the MOP are highly motivated even in a pandemic situation. Nonetheless, the urgent need for specific information addressed in the AQ does not always meet the individual circumstances of all respondents, leading to biased results. However, the AQ is an appropriate method to collect additional information in the MOP and should be further tested.

Acknowledgements

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