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Monitoring the impact of COVID-19 on the travel behavior of train travelers in the Netherlands

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Abstract

Mobility patterns and transport systems have been heavily impacted due to the COVID-19 pandemic. Public transport is impacted heavily, as governments worldwide advised against using it. This paper presents the data collection effort initiated by NS (Dutch Railways) and Delft University of Technology to capture changes in travel behavior, attitudes and intentions related to the COVID-19 pandemic among Dutch train travelers. The survey set-up, data collection process, data validation and potential of the dataset are discussed. The data collection effort proves to be a valuable longitudinal data set that is ground for many research opportunities and policy insights.

Keywords: longitudinal data collection; COVID-19; train travelers; travel behavior; survey design

1. Introduction

Mobility patterns and transport systems accordingly, have been substantially impacted due to the COVID-19 pandemic (De Vos, 2020). More specifically, worldwide the impact on public transport (PT) demand and supply have been enormous (Astroza et al., 2020; Bucsky, 2020; Jenelius and Cebecauer, 2020). In March 2020, first lockdowns, of what proved to be a series of lockdowns, were imposed by governments worldwide and PT usage dropped drastically, up to 90% in some places (Jenelius and Cebecauer, 2020; Ton et al., 2022). In sharp contrast to normal circumstances, governments (and PT agencies) advised to avoid PT where possible.

In addition to the challenges during the pandemic, PT operators and authorities continue to face challenges in the post-pandemic era. To ensure efficient and high-quality PT in the post-pandemic period, it is important to understand structural changes in current and future passenger behavior. This way, policies and plans can be adjusted accordingly and if needed, interventions in design and policy can be applied to influence the behavior in such a direction that they better match policy goals regarding, for example, sustainability and accessibility. Our hypothesis is that passenger

behavior will remain (to some extent) adjusted after the pandemic compared to the situation before. For instance, online education and teleworking are well established and might continue to be part of our daily routines (López-Igual and Rodriguez-Modroño, 2020; Ton et al., 2022).

To gain insights into passenger behavior during and after the pandemic, NS (Dutch Railways) and Delft University of Technology started a joint data collection and research amongst Dutch train travelers (van Hagen et al., 2021). Up to now, this longitudinal research consists of 6 waves, starting in April 2020 and ending in September 2021. The 7th wave was scheduled for April 2022 (time of writing is March 2022). This paper focuses on the data collection set-up and the methodological approach to this data collection effort.

The remainder of this paper is structured the following way. Section 2 provides insights into other longitudinal data collection efforts that arose during the pandemic. Section 3 discusses the design of the longitudinal survey. After that, section 4 presents the data collection effort. Section 5 discusses the validity of the data and section 6 provides insights into the opportunities of using the data for research. Finally, section 7 discusses the lessons learned and choices made in the data collection effort.

2. Longitudinal data collection efforts during COVID-19

The COVID-19 pandemic provided a unique opportunity for researchers worldwide to investigate and understand changes in travel behavior. Due to measures imposed by the governments, people were forced to break the habits they had developed over time and had to drastically change their travel patterns, with enormous impact on the transportation systems worldwide. Two approaches towards longitudinal data collection during the pandemic have been identified; 1) ongoing longitudinal data collection on travel behavior data from before and during the pandemic, 2) data collection initiatives that are organized during the pandemic at one specific moment but reflect on one or more previous periods to capture changes in behavior.

De Haas et al. (2020) follows the first approach. They collected data by distributing surveys among their existing Netherlands Mobility Panel (MPN) on changes in travel patterns. Because they already had longitudinal data from their panel on the situation before the pandemic started, they could capture very accurately what changed. Jenelius and Cebecauer (2020) made use of ridership data from Stockholm to capture changes in behavior. Hence, they had an objective ground truth for the pre-pandemic situation, but not the underlying reasoning for changes in travel behavior, like for De Haas et al. (2020). Finally, Molloy et al. (2021) used data collected from a mobility panel that commenced in September 2019 (pre-COVID-19) to capture ongoing changes in behavior. Through GPS tracking, supplemented with surveys, they could accurately capture changes.

Most studies follow the second approach, as no existing data collection efforts were in operation. For example, Currie et al. (2021) created a survey intending to capture travel patterns over time (longitudinal) focusing on commuting behavior in Australia. In their survey they asked people to report their commuting behavior before the pandemic, during the first lockdown, between the lockdowns (when the virus was still present), and during the second lockdown. Furthermore, they asked about expectations towards the future after the pandemic. This method will definitely provide insights into behavior during different phases of the pandemic. However, it relies heavily on the memory of the respondents that date back a longer time. This approach was also adopted by Anwari et al. (2021) in Bangladesh, Beck and Hensher (2020) in Australia, Awad-Núñez et al. (2021) in Spain, and Del Chiappa et al. (2021) in Italy.

3. Survey design

The data collection effort was initiated after COVID-19 had made its way into the Netherlands. Hence, our study also follows the second approach introduced in section 2. In the first wave of the data collection, we ask about the pre-pandemic situation to create a reference situation. Our study also resembles the first approach introduced in section 2, because we do collect data over multiple waves and time periods. The base survey for each wave consisted of four blocks and takes roughly 20 minutes to complete. The first wave included one additional block. The included blocks are the following:

- Socio-demographic information and train travel details in pre-COVID-19 times (only wave 1)
- Activity behavior and mode use behavior in the previous week (more detailed for train use)

- Attitudinal statements on COVID-19 in relation to infection, physical/digital contact, and teleworking/online education
- Attitudes towards modes
- Intentions for future travel behavior (more detailed for train use)

The first block (only wave 1) was included to collect background information on all the respondents and to be able to compare various groups of train travelers (e.g. gender, age, household composition, and care responsibilities in light of COVID-19). The second block asks about the objective travel (such as use of car, train and other modes) and activity (such as work, education, social trips) behavior of the respondents in the previous week. This is done to reduce the required effort of remembering activities and modes used in the past. To establish a reference point for the impact of COVID-19, we asked about the travel behavior and activities in a regular week in the pre-pandemic situation (February 2020). The activities and travel behavior are captured through various questions, where more detailed questions are formulated for train travel (e.g. travel duration, frequency, access and egress, and performed activities at the station). The third block consists of attitudinal statements, posed using a 5-point Likert-scale ranging from fully disagree to fully agree. The statements are posed neutral to positive for two reasons; the situation during the pandemic was automatically introducing negative feelings among the population and the government advised against using PT. The statements were divided into three blocks that were identified as potentially affecting train usage during the pandemic: 1) attitude towards infection (e.g. “I am afraid of contracting COVID-19”), 2) attitude towards physical/digital contact (e.g. “I avoid crowded places”), and 3) attitude towards teleworking/online education (e.g. “At home I can concentrate on my work”). The fourth block targeted the attitudes towards different modes (such as car, train, shared modes, and airplanes), also on a 5-point Likert scale ranging from very negative to very positive. Finally, the last block was focused on intentions towards future travel behavior (the same mode use and activities used in block 2). These questions were posed such that they asked about future intentions in relation to the behavior in the pre-COVID-19 situation, where the answers ranged from much less to much more (1-5 scale). Next to that, a more detailed question asked about the % increase or decrease in train use compared to the pre-pandemic situation. This information is used to estimate the actual impact of the changes in behavior.

Each wave also included a special topic, that was selected based on company interests or situations that arose specifically following the pandemic. Special topics that were included are teleworking possibilities (wave 1), vehicle purchasing behavior to replace train travel (wave 2 and 3), travel days and times before/during/after pandemic (wave 3), expectations around working in office versus at home (wave 3), home moving intentions and behavior (wave 4), vaccinations (wave 4), plans of employer regarding teleworking versus office work (wave 5), attitude towards measures taken by NS (wave 5), changes in subscriptions (wave 6), and first class travel (wave 6). Sometimes these special topics were included multiple times, in case longitudinal information for the topic was potentially interesting.

The five blocks of questions that were introduced in the first wave, formed the basis of each of the following waves of data collection. However, within these blocks - over time - several questions were excluded, for example when limited information was extracted or the answers given were focused too much to one side. Also, new questions were introduced when measures imposed by the governments changed, or because we learned from the previous wave of data.

4. Data collection effort

Since about 20 years NS has its own internet panel. Members of this panel participate in, mostly, online research, but also in focus groups on a wide variety of topics related to the train journey (e.g. door-to-door mobility, retail at stations, and train design). Currently, the internet panel consists of around 80,000 members. The NS panel is based on voluntary subscription of participants. This might result in unrepresentativeness of the panel in relation to the Dutch train travelling population, as it is generally expected that either very positive (“train lovers”) or very negative (“complainers”) people participate. Furthermore, participation is not rewarded in any way.

In April 2020, we distributed the first wave of our survey among all members of the internet panel by means of an online survey. Where response rates among the NS panel are usually around 30%, in the first wave our response rate was almost twice as high, resulting in almost 46,000 respondents. From open remarks in this first wave, it was clear that participants thought the subject was interesting and relevant. Also, it was the only data collection effort done at that time in this panel.

In the first wave we asked participants if they were willing to participate in future surveys on the effects of COVID-19 and 96% agreed (1,853 respondents dropped out). At that point, the first COVID-19 lockdown was in full effect and nobody knew yet how long this pandemic was going to last. We were planning on collecting longitudinal data, with the idea that when the measures imposed by the government or the general situation changed such that it might affect travel behavior, we would set up and distribute another wave to collect data. Figure 1 shows the timeline of the data collection efforts so far (as of March 2022).

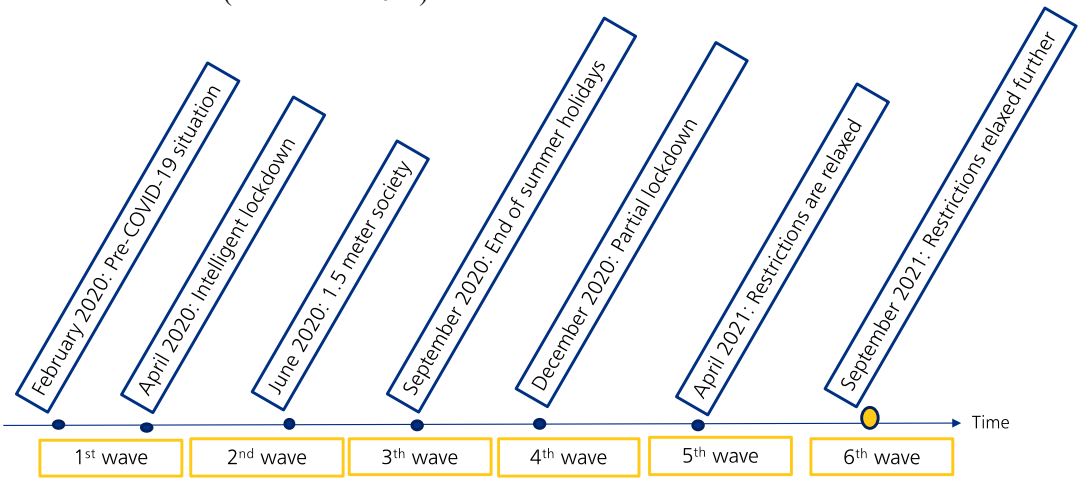

Figure 1: Timeline of data collection effort

We weight the results of each wave, such that it represents the Dutch train traveler population (as seen in 2019). As the NS internet panel has an overrepresentation of elderly, age is the first important weighting factor. Because we want to have insights into the expected number of train trips during and after COVID-19, train travelling frequency is a logical second one. Furthermore, as we expect behavior to mainly differ by trip purpose, this is the third factor. We divided the respondents into four age groups, three travelling frequency groups and four trip purposes. This gives a total of 4x3x4 = 48 weighting cells. As some weighting cells have few observations, they are grouped with adjacent cells. In the end this gives a total of 32 cells (see Table 1). Target distribution for all cells is derived from data of NS from 2019.

Table 1: Weighting cells to obtain representative results for the entire Dutch train travelling population (based on 2019)

		Frequency		
Trip purpose	**Age**	High (weekly)	Medium (monthly)	Low (yearly)
Commuting	18 - 34			
	35 - 54			
	55 - 64			
	65 +			
Educational	18 - 34			
	35 - 54			
	55 - 64			
	65 +			
Social	18 - 34			
	35 - 54			
	55 - 64			
	65 +			
Recreational	18 - 34			
	35 - 54			
	55 - 64			
	65 +			

When analyzing data of one wave, we apply the weighting factor for that specific survey. When analyzing data from multiple waves ideally a separate weighting procedure should be applied, taking into account only those respondents that participated in all surveys that are part of the specific analysis. As this would call multiple extra weighting procedures, depending on the combination of waves, we currently analyze the longitudinal data unweighted.

In each wave of the data collection, we invited those respondents who wanted to join the longitudinal research. Each wave some respondents dropped out, but also some that had dropped out in a previous wave renewed their participation, i.e. they did not participate in the previous wave, but are in the next (e.g. participation in wave 1 and 3) (Table 2). Though response gradually became less, the sixth wave in September 2021 still had over 18,000 respondents. Nearly half of them even participated in every wave. For this group of 8,879 respondents we have responses on the same questions at six different points in time, including data on each of the special subjects, making it a very rich data base on (train) travel behavior throughout and after the pandemic.

Table 2: Response in each wave of the data collection effort

Wave	Respondents	Dropped out	Renewed response
1: April 2020	45,937		
2: June 2020	30,632	13,452	0
3: September 2020	24,427	10,351	4,146
4: December 2020	23,202	7,686	6,461
5: April 20201	23,031	6,605	6,434
6: September 2021	18,185	8,841	3,995

5. Data validation

Results and insights gathered from the COVID-19 data collection effort play an important role in decision-making within NS. Therefore, it is necessary that the results from the survey are valid and a good predictor for actual behavior. Weighting, as discussed in section 4, ensures results are valid for the entire train traveler population. Next to that, three more actions are done to ensure validity: validate results with data/survey on an external panel (5.1), evaluate the trends in responses (5.2), and a comparison with external research (5.3).

5.1. Validation through a survey on an external panel

The first wave of the COVID-19 data collection effort, in April 2020, was complemented with respondents from an external panel. In this external panel we distributed the same survey to 1,600 respondents. Weighting was applied in the same way as the NS panel, to ensure a representative sample for the Dutch train travelling population. Then, some of the most important questions in the survey answers were compared: current and expected train usage, teleworking, anxiety of contamination with COVID-19, and attitude towards car and train. The (mean) results are visualized in Table 3.

Table 3: Results of validation with external panel

Question	NS panel	External panel	Units
Current teleworking frequency *	1,40	1,55	entire population, frequency per week
Current train use frequency	0,1	0,06	entire population, frequency per week
Anxiety of contamination with COVID-19	3,26	3,27	1=completely disagree, …, 5=completely agree
I like to travel by train *	2,46	2,77	1=completely disagree, …, 5=completely agree
Reason not to travel by train Rank 1 (out of 10)	Maintain distance from people	Maintain distance from people	
Reason not to travel by train Rank 2 (out of 10)	Discouraged by Government	Not touching potentially contaminated objects	

Reason not to travel by train Rank 3 (out of 10)	Not touching potentially contaminated objects	Discouraged by Government	
Attitude towards car *	3,69	3,38	1=very negative, …, 5=very positive
Attitude towards train	2,44	2,55	1=very negative, …, 5=very positive
Intention to future Teleworking *	3,11	3,37	only commuters; 1=much less, …, 5= much more
Intention to future train use	2,78	2,80	1=much less, …, 5= much more

*Significantly different on a 95% confidence interval

We can conclude that there are differences and about half of them prove to be statistically significant. Due to the large sample size, even small differences will be statistically significant. Therefore, it is also logical to look at the absolute differences to see if they are relevant. These absolute differences are small enough to give confidence in the validity of the NS panel for representing the Dutch train traveling population in this data collection effort and consequently, the resulting findings. The, from NS point of view, important question about the intention towards future train usage provides almost the same result (difference is insignificant, see also the distribution shown in Figure 2).

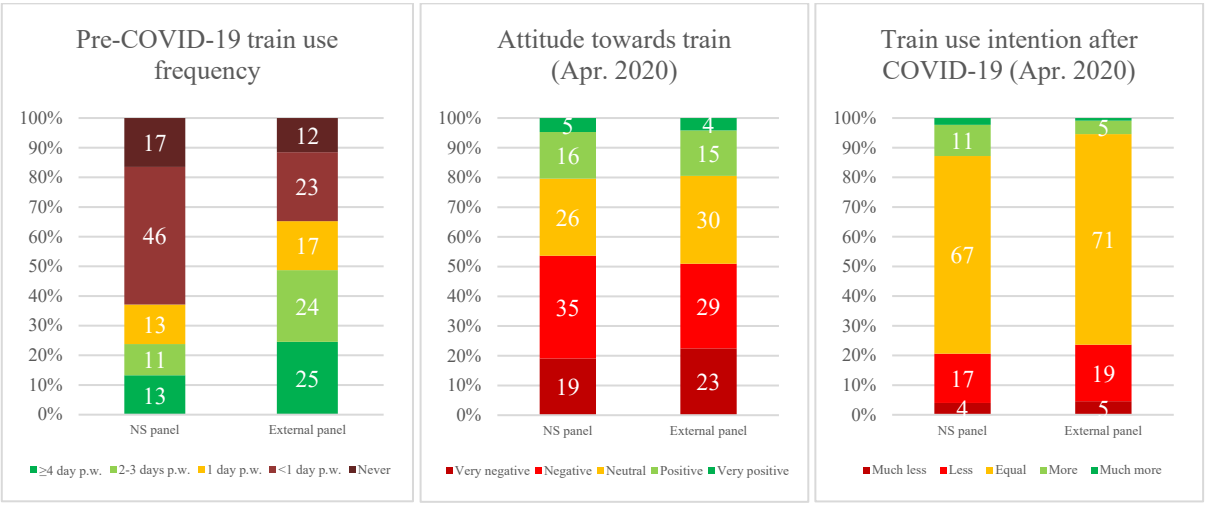

Figure 2: Distributions of NS versus external panel for three variables (both weighted according to table 1)

The train use frequency during COVID-19 (in April 2020) is similar for both panels, however when looking at the train use frequency in pre-COVID-19 times, the external panel consists of more high frequency users compared the NS panel. In both panels also non-users are included. In section 4, we mentioned that subscription of the panel is voluntary, and people are not compensated, which could result in either very positive or negative people signing up. Figure 2 shows that the distribution of attitudes towards the train for both panels are very similar.

5.2. Trends in responses

Many questions in the survey pertain to the COVID-19 at that moment. Therefore, we expect that the responses are not stable, but that they fluctuate with the COVID-19 severity (in number of cases/deaths) and measures imposed by the government. Hafsteinsdottir (2021) shows, using data from wave x and y, that this is indeed the case.

A second trend analysis is done on the questions about intentions after COVID-19. Responses to these questions are expected to be more stable. They might change with sudden different situations (such as the start of the pandemic) but will not vary too much while this situation (the pandemic) endures. Indeed, intentions about future train usage are very stable (see Figure 3). Repeatedly stated intentions become a better predictor of actual behavior (Sheeran and Webb, 2016). From this we can conclude that the stated intentions about future train usage are fit for use in actual forecasting.

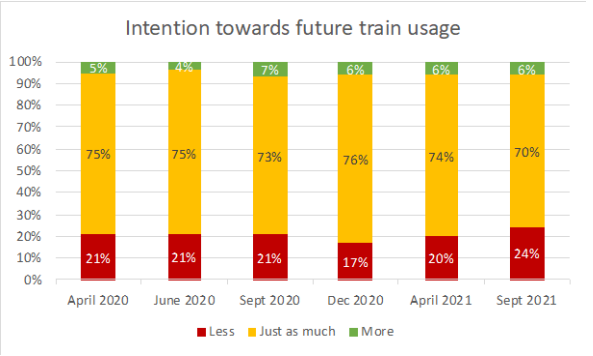

Figure 3: Intention towards future train use over time/waves (weighted per wave, includes all respondents per wave)

5.3. Comparison with external research

The Transport Policy Institute of the Netherlands did a meta-analysis on the effects of teleworking expectations after COVID-19 (Hamersma et al., 2020). The results from our data collection effort are fitting in the range of possible outcomes they have gathered from a variety of studies in the Netherlands. For instance, respectively 50% and 62% of the people in our data collection effort (wave 1 and 2) mentioned they are expecting to telework more often after the pandemic compared to before. This is within the interval of all studies listed, albeit quite high. This is as expected, as our research focusses on train travelers specifically, for whom we know that a relatively big part of them can easily telework (Ton et al., 2022).

The study by de Haas et al. (2020) uses data which was collected at the same time as our first wave and also originates from the Netherlands. The type of questions they asked is broader compared to our survey, as it focusses on generic changes in travel behavior whereas our survey focusses (more) on train travel behavior and related behaviors. However, generally their findings (on a smaller sample, which is considered representative for the entire Dutch population) and our findings match well. Several exceptions are found, due to the different target population. This is the case for, for example, train use and car use behavior.

The Dutch government reflects on the first COVID-19 year and provides an outlook towards future expectations in “Mobiliteitsbeeld” (KiM, 2021). When comparing specifically their findings regarding future expectations and our own findings, we see comparable results. They found that the effect on travel behavior of commuters would be the largest, which we also identified. Furthermore, they found that the second effect is that people will switch their mode choice from train to car, which, to a certain extent, we also found.

Hence, compared to other studies in the Netherlands (with different target groups) we find comparable results on various aspects like teleworking, travel behavior and future expectations. This also that shows that the data collection effort results with valid data.

6. Opportunities for research

The data collection effort resulted with a very rich data set over (currently) six waves of data. The possibilities with this data are huge and a variety of studies have already been performed, for example on teleworking (Ton et al. 2022), the relationship over time between attitude towards modes and mode use (Dirkzwager, 2021), and the effect of anxiety on train travelling behavior (Hafsteinsdottir, 2021). This data collection effort can be used to investigate various types of relationships that can be categorized in the following ways; 1) cross-sectional comparison within a wave to identify relationships between variables for the Dutch train travelling population, 2) weighted comparison over time for the Dutch train travelling population for the same variables 3) longitudinal within individual comparison over time, to identify trends, changes and relationships from one wave to another (not weighted), and 4) longitudinal within individual comparison over time where the relationships between variables included in different waves are investigated (not weighted). Sections 6.1 through 6.4 show an example of each of these categories of relationships that can be investigated using the data.

6.1. Cross-sectional comparison: feeling welcome in the train

In September 2020 (wave 3), the Netherlands experienced the first situation where travel was possible beyond only necessary travel. Since the start of the pandemic, the government had advised against using PT. Hence, for NS, one of the important statements in the third wave was "I feel welcome at NS (in the train)". Of the train travelers, 80% agreed that they felt welcome, 16% were neutral to the statement, and the remaining 4% disagreed. We investigated the differences between the travelers that felt welcome versus those that did not.

The travelers that felt welcome at NS had some different characteristics in comparison to the travelers that did not feel welcome. The statistically significant differences (on a 95% confidence interval) between these groups are shown below. Those that felt welcome:

- made longer train trips (duration)
- were often more afraid of contaminating other people
- were more often fine wearing a face mask
- felt like they could better maintain 1.5-meter distance at the station
- felt safer at the station
- experienced the help of staff more often as pleasant
- felt more often that appropriate measures were taken
- felt more often that they themselves and the people around them obliged the rules
- had a more positive attitude towards the train
- were more often expecting to travel frequently by train after the pandemic

These findings show that the travelers that feel welcome at NS and in the train are more aware of the COVID-19 situation and feel like they can travel safely, given all the measures. Since the vast majority of the travelers did feel welcome, this suggests to NS that the measures put in place paid off in terms of traveler satisfaction.

6.2. Weighted comparison over time: intention towards future train usage

Many questions in the surveys have been repeated in every wave, allowing for a weighted comparison over time for the Dutch train travelling population. As mentioned before, one of the questions, that is particularly relevant for NS, is the intention towards future train usage. Figure 3 shows the intention towards future train usage, weighted per wave for the entire population. It shows that the vast majority intends to use the train just as much as they did before COVID-19. As we also know the frequency of travel before the pandemic, this can help us make predictions of future train use. Furthermore, a small share of the population intends to travel more often or less often by train. The follow-up question asks about the reason for intending to travel more or less. The most frequently mentioned reasons for travelling more often are more social/recreational trips by train, because of sustainability, and because of switching jobs. People intend to travel less often because of teleworking, using a different transport mode and less recreational trips.

6.3. Population changes: vaccination and train usage

From waves 4, 5 and 6 we can investigate the effect of vaccination on train usage. The Netherlands started vaccinating its inhabitants at the end of December 2020, meaning that in wave 4 nobody was vaccinated. By April 2021 (wave 5) mostly people of 60 years and older had gotten their first vaccination, and some people of 70 years and older were completely vaccinated (two doses, according to policy). In September 2021 roughly 80% of the Dutch population of 12 and older had all vaccinations. This means that there were a lot of changes in vaccination status between waves 4, 5 and 6. We look at changes in train usage per vaccination status group, see Table 4. The study of Hafsteindottir (2021) reflects on this relationship in more detail.

Table 4: Impact of changing vaccination status on train usage

Vaccination status			Vaccination status		
Wave 4	**Wave 5**	**change in train usage**	**Wave 5**	**Wave 6**	**change in train usage**

Not vaccinated	All vaccinations	23%	Planning vaccination	All vaccinations	73%
Not vaccinated	Partially vaccinated	-10%	Partially vaccinated	All vaccinations	98%
Not vaccinated	Planning vaccination	3%	All vaccinations	All vaccinations	68%
Refuse/don't know	Refuse/don't know	-1%	Refuse/don't know	All vaccinations	42%
			Refuse/don't know	Refuse/don't know	32%
Average change		*1%*	*Average change*		*77%*

From wave 4 to 5 train usage remained roughly the same (only 1% increase). However, within the group that got fully vaccinated it rose 23%, which is much higher than the other groups, suggesting more comfort or safety travelling by train. Between waves 5 and 6 the average train usage increased drastically (77%). The change was highest for the group that was partially vaccinated in wave 5, and fully in wave 6 (98%). By doing these within-respondents analyses we gain insights in the causes of changes in travel behavior.

6.4. Comparison between different variables over waves: intention towards train use and purchase of vehicle

To better understand the intentions towards future train use, we also investigated the relationship with vehicle purchases that were meant to replace train travel. This question was posed to respondents in waves 2 and 3. Only few (32 respondents) purchased a vehicle to replace train travel. As we asked about intentions towards train usage after the pandemic in all waves, we can make a comparison between before and after purchasing the vehicle. Table 5 shows the share of respondents, categorized on whether or not they purchased a vehicle, that intends to travel less by train after the pandemic ends. This share is significantly higher among the people that did purchase a vehicle compared to those that did not, both before and after the purchase. This suggests that some plans for purchasing a vehicle were already made during the first wave. As expected, the percentage increased after the purchase of a vehicle, whereas this did not change for the other respondents.

Table 5: Share of respondents that intent to travel less by train after the pandemic

	Wave 1 (April 2020)	**Wave 4 (December 2020)**
Purchased a vehicle to replace train travel	41%	59%
Did not purchase a vehicle	20%	19%

7. Discussion on the lessons learned

This paper presented the data collection effort initiated by NS and Delft University of Technology to capture changing travel behavior, attitudes and intentions due to the COVID-19 pandemic among Dutch train travelers. The survey set-up, data collection process, data validation and potential of the dataset have been discussed. This last section reflects on the choices that have been made during the data collection effort and how they might have impacted the resulting data.

In April 2020 (wave 1) the entire panel was invited to participate in the data collection effort. This was possible because no other data collection was going on at that time (in terms of over-asking respondents). We continued with those panel members that participated in the first wave and mentioned they would like to participate in further surveys. This meant that 34,000 panel members were excluded from the data collection based on this decision. With the declining participation rate, it is interesting to invite these people again in the data collection effort. This entails that we have no prior information on these individuals during the pandemic, however depending on the remaining duration of the pandemic and thus data collection effort, we could still build up a longitudinal dataset and hence would strengthen the sample size per wave. In hindsight, this decision could have been taken earlier, e.g., after wave 5. It is, however, difficult to anticipate how many times respondents are willing to participate when starting such a data collection effort.

In the ideal situation we would have data on travel behavior, attitudes and intentions of the panel members from before the pandemic as well, as this allows for observation of actual changes (like in de Haas et al. (2020)). We managed to (partially) overcome this issue by asking the respondents about their behavior before the pandemic, however this asks a lot of a respondents' memory. Especially in a new situation (such as a pandemic) it might be difficult to relate to a previous situation. Having a similar survey for the period before the pandemic would have

definitely helped in the attitudinal questions, like perception of crowdedness or attitude towards modes. We follow up on this by introducing a standard survey on a yearly basis that provides information on travel behavior, attitudes, life events etc. Currently, recurring surveys like this only ask about whether the panel members' information is up to date, but this can be extended with questions that provide basic insights over time.

When the data collection effort commenced, we did not know how long the pandemic would last nor how many waves of data collection we would have. Now it seems that there will at least be 7 waves of data and potentially more, given the progress of the pandemic. When reflecting on the choices and timing of the waves, we see that next to waves coinciding with changes in the measures, they also sometimes coincide with business planning periods within NS. So, not only when we expected changes in behavior due to changes in measures, but also when policy input was required. The latter holds for example for both the April waves (1 and 5). In hindsight, it would have been better to match the timing of all waves with changes in measures that might have affected travel behavior. Furthermore, because of learning from previous waves, we also included more questions in later waves that were not included in the first waves (such as those relating to impediments that prevent people from travelling by train). Ideally, this would have been stable over time, but the longitudinal character of this data collection effort ensures that learning takes place over time.

Finally, next to recurring closed-form questions, we asked a wide variety of open questions. These questions contain rich information and have sometimes resulted in new answer alternatives or new questions. Many more variables were extracted by using this approach (over the course of 6 waves we identify around 2,500 variables). The information gathered using this approach provides additional insights into the top-of-mind topics of respondents (frustrations and ideas), which results in richer data compared to pre-defined answers. We use topic modelling to analyze the answers to the open questions.

In sum, this data collection effort proves to be a valuable longitudinal data set that is ground for many research opportunities and policy insights and provides valuable lessons for future longitudinal data collection efforts.

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CRediT author statement

Danique Ton: Conceptualization, Methodology, Data collection, Formal analysis, Writing – original draft, Writing – review & editing, **Menno de Bruyn:** Data collection, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, **Mark van Hagen:** Data collection, Methodology, **Dorine Duives:** Data collection, **Niels van Oort**: Data collection, Writing – review & editing.

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