## People with disabilities in on-demand ridepooling: revealed demand patterns of wheelchair users and severely disabled passengers of MOIA in Hamburg

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#### SHORT SUMMARY

In 2023, MOIA, an on-demand ridepooling operator, was integrated into Hamburg's public transport network, introducing wheelchair-accessible vehicles and subsidized fares for severely disabled individuals. This study analyzes one year of demand patterns in Hamburg following these enhancements, utilizing data analyses to assess their impact on service usage and accessibility. Findings reveal insights into distinct spatio-temporal user behavior, offering valuable guidance for the development of large-scale urban mobility solutions.

#### Keywords:

accessible transportation; demand-responsive transit; ride-pooling; wheelchair-accessible

#### **1** INTRODUCTION

Modern mobility services such as ride-hailing and ride-sharing offer convenient alternatives of travel. Recently, various providers such as Uber, Via, Lyft, DiDi or MOIA emerged into the market. While ride-hailing services resemble conventional taxi services where each request is served individually, ride-sharing services aim to pool trips that are similar in space and time and thereby promise to be more efficient. Lately, providers also started offering their service for wheelchair users who may benefit greatly from this additional mobility option. To be able to offer such a service, operators have to provide vehicles that are designed to carry wheelchair users. Often, only a part of the fleet consists of wheelchair-accessible vehicles (WAV), as these require specific space and possible additional installations such as lifts and ramps.

So far, little is known about the specific observed demand patterns of severely disabled persons and wheelchair users in on-demand settings. In Germany, there is no official statistic on the share of the population requiring a wheelchair. While there are studies that assess wheelchair-accessible ridehailing and -pooling services with the help of models, expected demand remains an issue (Bischoff et al., 2017; Macfarlane et al., 2021). Regarding the volume of demand, figures like the ones published as part of the Public Accessibility Reports for the California Public Utilities Commission (CPUC, 2022) exist but are limited to US applications only, which is not easily transferable to European conditions, especially since public transportation tends to be more exhaustively available in Europe, providing additional options for mobility-impaired persons (given accessible infrastructure and vehicles). For the two larger companies Uber and Lyft, it can be seen that demand for WAVs stays well below 1 % of the total number of served rides in California (CPUC, 2022). Brown et al. (2021) report that fewer than 1 % of trips requested in a pilot program with the operator Via in Los Angeles were for WAVs. Brumbaugh (2018) shows that only 4.6 % of the people with disabilities used ride-hailing services at least once in the last 30 days (compared to 12.4 percent of people aged 18 to 64 without disabilities). Choi & Maisel (2022) give an overview of on-demand transport usage for people with disabilities in the North American context.

This study presents findings of the first year of introducing a WAV fleet as well as discounts for severely disabled persons in the on-demand ride-pooling service MOIA in Hamburg, Germany. MOIA has been part of Hamburg's public transport system since 2023, accompanied by the introduction of 15 wheelchair-accessible vehicles. The vehicles shown in figure 1 have four regular seats and room for one wheelchair. The experience is designed to be inclusive, meaning that wheelchair users may be pooled with other passengers along the trip. The newly introduced discounts for



Figure 1: Impressions of MOIAs wheelchair-accessible vehicle, which is based on a VW e-crafter.

severely disabled persons are provided for eligible customers who registered their status in advance. In that case, the ride for the customer and up to one accompanying person is free of charge.

## 2 Methodology

To analyze the observed demand, anonymized request data for the complete year of 2023 is evaluated. Since not every recorded user request eventually leads to a booking (users may not accept an offer or MOIA cannot make an offer), demand does not equal served rides. Besides customer ID, timestamp, group size and origin/destination, the need for a WAV or the qualification for a severely disabled person discount is known for each request.

## 3 Results and discussion

2,083,287 requests have been estimated by MOIA in the entire year 2023. Out of these, 218,330 or 10.5 % qualified for a severely disabled price discount. In addition, 27,373 requests were submitted by wheelchair users, which is roughly 1.3 % of all requests in 2023. Among those, 21,821 (79.7 %) also qualified for a severely disabled person discount, which means that there are quite a few wheelchair users who did not register for the discount, even though the vast majority should be eligible for it. Figure 2 shows the different set sizes and their respective overlap.

Figure 3 shows the evolution of requests requiring a wheelchair and qualifying for a severely disabled discount over the year (52 calendar weeks in 2023). It can be seen that the demand increased steadily at first and became more stable towards the end of the year. Especially in terms of wheelchair requests, it must be noted that the supply is also limited as the WAV fleet is considerably smaller than the regular fleet of vehicles, so the saturation can also be an outcome of a demand-supply equilibrium. Interestingly, the demand dropped significantly in the last calendar week which can be explained by holidays between Christmas and New Year. Given that not only



Figure 2: Comparison of number of requests requiring a wheelchair and/or qualifying for a severely disabled person discount (circle sizes not proportional).

the absolute numbers but also the shares of total requests drop, this can be a first hint at different usage patterns when compared to customers without disabilities, for which it is known that MOIA is usually used for leisure purposes.

Another indication of distinct usage patterns can be seen in figure 4. It becomes clear that disabled passengers (with or without wheelchairs) show different temporal usage frequencies on average when compared to customers who are not registered as severely disabled persons. Considering the daily patterns, the demand of disabled persons is relatively more stable throughout the week and does not show a pronounced peak during the weekend, which is the usual peak hour for the MOIA service. Similarly, disabled customers seem to use MOIA more during the day, whereas the typical MOIA demand curve shows a strong 'double peak' in the evening, when a lot of after-work leisure trips are taken. This is another indication that disabled customers may use MOIA more for daily trips such as going to work, shopping or visiting a doctor. The temporal difference is in line with the discussion of (Hassanpour et al., 2021) who reports that the national household travel survey in the US shows a strong single peak in the temporal distribution of trips of wheelchair users as opposed to the classic peak hour distribution during commute hours.

Another interesting finding concerns the usage behavior in terms of pre-booked versus ad-hoc requests. Before the introduction of the on-demand WAV fleet, wheelchair users often relied on paratransit services that had to be scheduled long in advance. This user group is used to planning trips in advance, always having to consider the accessibility of vehicles and facilities. In addition, wheelchair users and severely disabled persons may be more reliant on a specific accessible option, given that there might be no alternative. As such, it is meaningful to use the pre-booking feature as these trips generally are not rejected after they have been confirmed. For some people with disabilities, it may also take longer to get ready to depart. Pre-booked trips have to be requested more than one and up to 24 hours in advance. The increased usage of pre-booked rides can be seen in figure 5.

Figure 6 shows the distribution of requested group sizes. It can be seen that wheelchair users considerably more often request rides together with a second person - which might be related to the accompanying person who is included in the severely disabled person discount for which most



Figure 3: Absolute number of requests and share of total requests requiring a WAV (top) and qualifying for a severely disabled person discount (bottom) over the course of the year.



Figure 4: Absolute number of requests and share of total requests requiring a WAV (top) and qualifying for a severely disabled person discount (bottom) during days of the week and hours of the day (averages).



Figure 5: Mean share of pre-booked rides per day of week for wheelchair users (top) and severely disabled persons (bottom), compared to all requests, respectively.

of the wheelchair users qualify. When looking at all requests qualifying for the discount, it can be seen that these are requested more often by people traveling alone. It should be noted, that the maximum group size for requests requiring a WAV cannot exceed four because of capacity limits.

Figure 7 shows the spatially distributed density of origins of all requests (a), wheelchair requests (b) and requests with severely disabled person discounts(c). Looking at all requests, they tend to be concentrated in the city center of Hamburg, around the lake Alster and at the airport, which is in line with a detailed investigation of MOIA ride distributions by Zwick & Axhausen (2022). The spatial patterns of wheelchair users and severely disabled persons are different in that the outskirts of the service area attract way more requests. In particular the wheelchair requests are almost equally distributed in the service area. To identify the influencing factors of these demand patterns, further investigations like surveys and spatial regressions may help. When looking at average direct ride distances (i.e., distances between origin and destination without pooling), there only seem to be small differences between wheelchair users (7.798 km), severely disabled persons (8.187 km) and all requests (7.721 km).



Figure 6: Absolute number of requests and share of total requests requiring a WAV (top) and qualifying for a severely disabled person discount (bottom) over the course of the year.









Figure 7: Spatial distribution of demand density. a) Total requests b) Wheelchair requests c) Severely disabled requests

## 4 CONCLUSIONS

The revealed demand patterns show that on-demand ridepooling services may be an attractive option for people with disabilities and/or people requiring a wheelchair. It becomes obvious that it may take a while for users to adapt to a new offer. Looking at the temporal and spatial distributions of demand, distinct usage patterns emerge when compared to people without disabilities or wheelchairs.

A limitation of the study is that it is only recorded if requests are eligible for the severely disabled discount or not. There might be even more disabled customers who have not officially registered for the discount at MOIA yet. In addition, demand may even be underestimated, as the limited supply can also lead to a long-term equilibrium in which the demand levels have adjusted over time.

Given that demand shares and usage patterns are similar across cities or regions, the findings may help policymakers, planners and operators to prepare for new accessible services in new areas and to accurately plan for the correct supply. The figures may also help governmental institutions that struggle to regulate accessible services (Ward, 2017).

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# Declaration of Interests

It is declared that all authors of this paper are employed at the ride-pooling operator MOIA at the time of writing.

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