



Who Benefits from Mobility as a Service? A GIS-Based Investigation of the Population Served by Four Ride-Pooling Schemes in Hamburg, Germany

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Abstract

The emergence of Mobility as a Service (MaaS) holds the potential to satisfy passengers' needs more flexibly than conventional public transport, while being more affordable than traditional taxi services. This paper examines the potential benefits of ride-pooling schemes for low-income urbanites. Using a GIS-based method, I examine four schemes in Hamburg regarding their coverage of public welfare recipients. Three out of four schemes potentially serve a population with a lower share of public welfare recipients compared to the Hamburg average. Furthermore, the populations in their service areas have a lower share of elderly people. One scheme stands out regarding both welfare recipient share and elderly resident share. Due to municipal requirement, its fare is much lower than the other schemes' fares. From a low-income population's perspective, only this scheme holds the potential to enable the urban poor to partake in MaaS.

Keywords Mobility as a service · Urban poverty · Transport disadvantage · Ride-pooling · Digitalisation · Europe · Hamburg

Zusammenfassung

Urbanes Ridepooling ist Teil des Versuchs, Mobility as a Service in Hamburg zu etablieren. Es bietet die Möglichkeit, klassischen öffentlichen Nahverkehr flexibel zu ergänzen. Christoph Aberles Beitrag stellt die potenzielle Nutzbarkeit des Ridepoolings für Menschen in Einkommensarmut in den Mittelpunkt. Anhand einer GIS-basierten Methode werden vier Angebote (ioki, CleverShuttle, MOIA, mytaxi match bzw. FREE NOW) hinsichtlich sozio-demografischer Merkmale der Population untersucht, die potenziell bedient wird. Bis auf einen Ausnahmefall – ioki am westlichen Stadtrand – bedienen die Anbieter zentrale Gebiete, in denen weniger Menschen arm sind, weniger Menschen alt sind und die dichter besiedelt sind als der Hamburger Durchschnitt. Diese Gebiete bieten mutmaßlich bessere Voraussetzungen für einen wirtschaftlichen Betrieb als iokis Bedienungsgebiet. Im Gegensatz dazu operiert ioki in einem Gebiet, das aus Betriebssicht nicht optimal ist – schafft damit allerdings einen konkreten Nutzen auch für Menschen in Armut.

1 Introduction

1.1 Mobility as a Service, Its Social Relevance and Ride-Pooling in Hamburg

The ubiquitous availability of mobile devices in many urban areas holds opportunities for the provision of public mobility. The so-called Mobility as a Service (MaaS) schemes flexibly complement mass transport while being less costly than traditional taxi services. Building on information and communication technologies (ICT), MaaS comprises various modes, such as conventional bus/rail transport and bike-sharing schemes as well as flexible transportation offers like

The spatial data used for this paper can be accessed in the *TUHH Open Research Repository*: <https://doi.org/10.15480/336.2396.2>.

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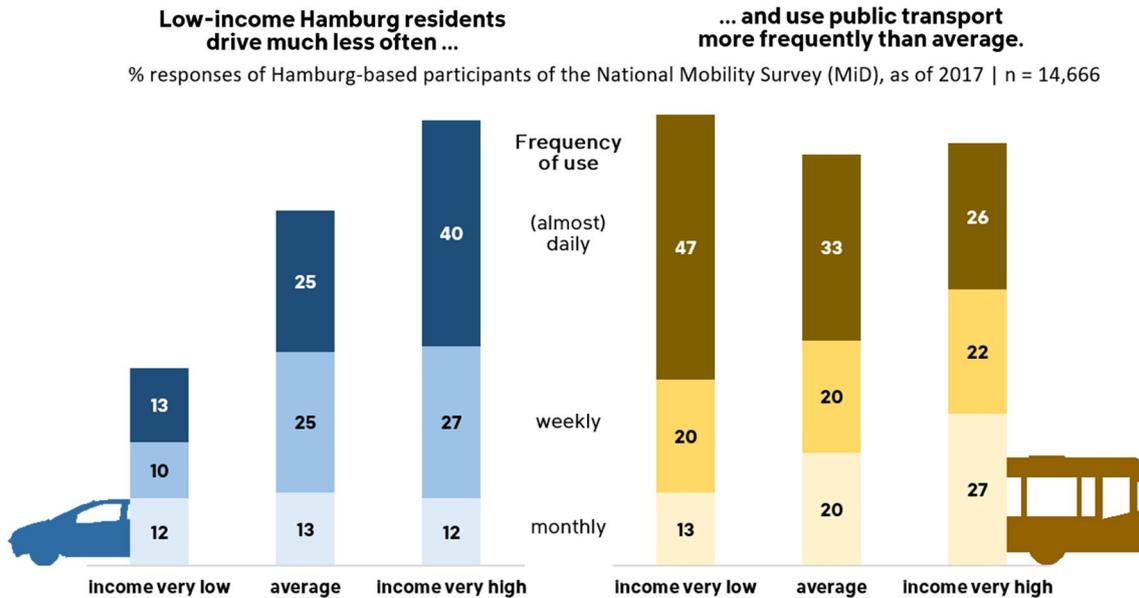


Fig. 1 Selected results of the 2017 National Mobility Survey (Mobilität in Deutschland), only responses from Hamburg. Income classes: very low <900 EUR per month per persons after deductions/aver-

age <2,600 EUR – “-/very high $\geq 4,000$ EUR – “. Own illustration based on infas, 2019, pp. 17–18

ride-pooling, all of which are digitally presented by a single interface and are freely combinable to suit situational mobility needs (Jittrapirom et al. 2017; Viergutz and Brinkmann 2018). In this paper, my focus is on ride-pooling, defined as a commercial passenger transportation scheme that is governed by municipal administration and run by private or (partly) public operators (Deutsch 2018; Mehlert 2019).

In preparation for the World Congress on Intelligent Transport Systems (ITS) in October 2021, the City of Hamburg, Germany has declared MaaS to be one of five pillars of transport modernisation pursued within a smart city framework. Generally speaking, smart cities use ICT to innovate urban areas in several realms including mobility, environment and governance (Albino et al. 2015). Specifically, the City of Hamburg aims to improve transport efficiency, environmental performance, and liveability through ICT-based transport innovations (Bürgerschaft der FHH 2018). While the smart city framework typically focuses more on technical infrastructure than on social intervention, the City of Hamburg has also identified the aim to deliver equal mobility options for economically deprived groups (BWVI 2018).

In this context, the city has granted permissions to three ride-pooling schemes to operate: *MOIA*, *CleverShuttle* and *ioki* (BWVI 2019). A fourth scheme, *mytaxi match* (now called *FREE NOW*¹), is not administratively speaking a

ride-pooling scheme, but I include it in this investigation as, from a passengers' point of view, it provides an almost identical service.² While the ride-pooling schemes currently have an experimental character, the City of Hamburg has plans to eventually integrate them into the public transport system (Aigner 2019).

A ride-pooling journey is usually arranged and billed using a smartphone app. In contrast to a conventional taxi service, several passengers may be picked up and dropped off, and unlike conventional taxi schemes, the operator may limit the service to certain operating hours. A ride-pooling journey does not necessarily follow the shortest route but is calculated by an algorithm as a trade-off between all passengers' origins and destinations. A journey can be booked within a respective service area: the service areas referred to in this paper are shown in Fig. 2 below.

The ride-pooling operators promise to offer increased mobility for urban dwellers while curbing negative externalities of (private motorised) transport such as road congestion and air pollution. Whether these promises hold true remains open. Furthermore, alongside evidence of worse environmental performance compared to conventional public transport (Burgdorf et al. 2019; Schaller 2018) and

¹ In July 2019, *mytaxi match* was relaunched as *FREE NOW*. As I had obtained the research data referred to in this paper prior to the relaunch, I use the service's former name here. Also, *CleverShuttle* ceased operations in October 2019 due to financial reasons.

² *mytaxi match*: it runs a taxi-booking service according to special regulation by the Passenger Transport Act/§51PBefG and the Hamburg Taxi Directive/§2(10) Taxenordnung (*mytaxi* (2019)), while the other services are operated according to §§42 / 2(6) and §2(7) PBefG, respectively. From a passengers' point of view, however, this formal difference is negligible.

concerns regarding data control in smart cities (Calzada and Cobo 2015), there are issues around who benefits from digitalised services—and who does not (van Deursen and Helsper 2015). Particularly in the context of public transport—something that economically deprived persons depend on in a particular way (Lucas 2012) and that low-income citizens of Hamburg use extraordinarily often (Fig. 1)—questions about the accessibility and affordability of these new services arise.

1.2 Aim of this Paper

This paper investigates the potential utility of ride-pooling for the urban poor population in Hamburg. Using a GIS-based method, I examine four schemes regarding socio-economic indicators of the population that is potentially being served. The assumption is that the spatialised distribution of urban inequality, which has been well investigated both in a North American and a European context (Florida 2015; e.g., Marcinczak et al. 2016; Nightingale 2012), is being reflected in accessibility to MaaS schemes. Applying a spatial approach to this question contributes to understanding about the interrelations of new mobility and its utility for certain groups. On a practical note, the topic is particularly relevant as virtually all ride-pooling schemes in Germany are being run on an experimental basis for a limited time (according to §2(7) Passenger Transport Act/PBefG). It is, therefore, a key moment for political decision makers to evaluate the offers and develop suitable approaches for long-term governance (Schwedde and Rammert 2020). Further, low-income persons have so far been largely ignored as a relevant group by transport planning.

Consequentially, this paper contributes to the debate around whether, and how, new mobility can contribute to an inclusive urbanity. By focusing on public welfare recipients—a group of the German society that is vulnerable to rising living costs and more threatened by social exclusion than any other (Häußermann et al. 2004)—I argue that three of four Hamburg-based MaaS schemes do not contribute to inclusion. Ride-pooling schemes can, however, deliver utility also for low-income groups, as the fourth example shows.

2 Method: GIS-Based Investigation Of Ride-Pooling Service Areas

To quantify the residents who are potentially being served by the ride-pooling schemes, I applied a spatial join to the operators' service areas, to selected 2018 socio-demographics and resident data from the 2011 census. The spatial join is a well-established method to relate spatial data that originate from different sources (e.g., Wang 2006).

The service areas were derived from the operators' web-pages or (where necessary) digitised manually. To obtain the share of welfare recipients (welfare according to Sozialgesetzbuch II/"Hartz IV" legislation), I used data delivered by the Municipal Statistics Body (Statistik Nord) as well as dwelling data provided by infas360. Notably, the welfare share was synthesised by dividing the absolute number of welfare recipients by the number of residents, which meant the data needed to be cleaned of artefacts (Table 1).

All data are available in a 100 m grid resolution. To include residents that live not within but close to a service area, I extended each service area by a buffer of 300 m, according to a German operational standard for urban public transport catchment areas (Allgemeiner Ausschuss für Planung 2019, p. 15).

3 Results

3.1 Ride-Pooling Schemes Concentrate in Areas with Low Welfare Share

Potentially, 1.1 M Hamburg residents (62.1%) have access to at least one ride-pooling scheme, i.e., live within at least one service area or up to 300 m outside the area. Relevant indicators of the four offers are summarised in Table 1.

It is noticeable that the service areas concentrate in Hamburg's core agglomeration north of the Elbe river (Figs. 2, 3). This might be due to the expectation of gaining a higher density of customers who are IT-savvy and willing (and able) to pay than in peripheral locations. In addition, the Elbe river forms a barrier to the southern districts, which limits the network and pooling potential throughout Hamburg. The river is only bridged by two major road connections that connect the Northern and Southern parts of Hamburg. These links (a tunnel and a bridge) are subject to congestion on a daily basis. For ride-pooling operators, they pose the risk of vehicles getting stuck in traffic jams—a situation that would jeopardise overall service level even if only few vehicles were affected.

The exception concerning service area is the *ioki* scheme whose service area is located on the western outskirts of the city, is considerably smaller than that of the other schemes (Fig. 2b, Table 1) and includes the large 1960s housing estate Osdorfer Born, which has been a cluster of urban deprivation for decades (Fig. 5). *ioki*'s connection of peripheral areas to new mobility services was a precondition for the municipal administration to authorise the scheme (Aigner 2019). Furthermore, *ioki* journeys were initially fully included in the Hamburg public transport tariff. Since April 2019, however, a surplus fare of 1 EUR has been levied for each trip to prevent "joyrides", primarily undertaken by young people (ibid., translated by the author; VHH 2019b).

Table 1 Operational and socio-demographic indicators of the four investigated ride-pooling schemes

Ride-pooling scheme + 300 m buffer	Operational indicators of the ride-pooling schemes				Socio-demographic indicators of the population potentially served by the ride-pooling schemes			
	Size of service area	Share of settlement area	Dwelling density, measured by settlement area (for service areas incl. 300 m buffer)	Fare for 5 km	Potentially served residents	Share of potentially served residents	Share of persons on public welfare	Share of persons older than 64 years
	km ²	%	Residents/km ²	EUR/ride ^a	Persons	%	%	%
<i>ioki</i>	20	5	6,532	1	73,680	4.0	19.9	20.9
<i>CleverShuttle</i>	134	26	14,267	5–6	809,382	44.4	12.0	18.5
<i>mytaxi match</i>	141	22	15,857	9–12	775,872	42.5	12.3	18.2
<i>MOIA</i>	211	46	10,550	5–8	1,080,271	59.2	13.5	18.9
Combined	240	49	10,489	n/n	1,133,458	62.1	14.0	18.9
Hamburg average	n/n	n/n	8,267	n/n	n/n	n/n	14.9 ^b	19.1
Reference date	2019	2018	2018	2019	2018	2018	2018	2011
Data source	Own calculation based on service areas	Hamburg Ministry of Urban Development and Housing (BSW)	infas360/BSW	Own booking requests	infas360	infas360	infas360/Hamburg Statistics Body	Census

^aCosts derived from 5 km booking requests from an address in Hamburg's Central Business District (*Große Theaterstraße 1A*) to a destination in a residential area (*Lortzingstraße 8*). The requests were deployed three times for each scheme at different times of day. All schemes besides *ioki* charge variable prices depending on origin/destination, time of day, and other passengers' demand. Furthermore, *ioki* only operates in a small area (see Fig. 2) and cannot offer rides across the city. If combined with conventional transport, the individual ticket fare has to be added to the 1 EUR cost of this, thus, only a very general comparison can be made

^bThe welfare share is higher than the real share, as low numbers were blurred by the Statistics Body due to privacy reasons. Each census cell with < 10 residents on welfare was assigned the value 5 (8,116 of 12,931 cells, equalling 62%). As a consequence, cells with a population of < 20 were excluded from the analysis as they would distort the welfare share for the higher. The number of excluded cells is 894 (6.9%). According to the Statistics Body, the average welfare recipient share for Hamburg is 9.7%. However, for this indicator I am interested in the relationship between the different schemes and the Hamburg average. Using a slightly different methodology, I have compared the schemes using a lower spatial resolution and found similar results; see Aberle (in press)

Figure 3 shows the area served by at least one ride-pooling scheme, representing 32% of the municipal territory or 49% of Hamburg's settlement area (Table 1). Thus, generally speaking, Hamburg's ride-pooling schemes operate in areas that already have a decent level of public transport service. As Fig. 3b shows, however, there exist areas in between railway corridors that benefit from ride-pooling. One of these service gaps is filled by *ioki*, as Fig. 5 points out.

3.2 The Urban Poor are Underrepresented in Ride-Pooling Service Areas

People living on public welfare are underrepresented when it comes to the three large ride-pooling schemes: in the service areas of *CleverShuttle*, *MOIA* and *mytaxi match*, the public welfare recipient share is lower than the Hamburg average. It is only in *ioki*'s service area that the share exceeds the

average (Table 1, Fig. 4). The same applies to the share of persons older than 64: only *ioki* serves a higher share of elderly people compared to the Hamburg average.

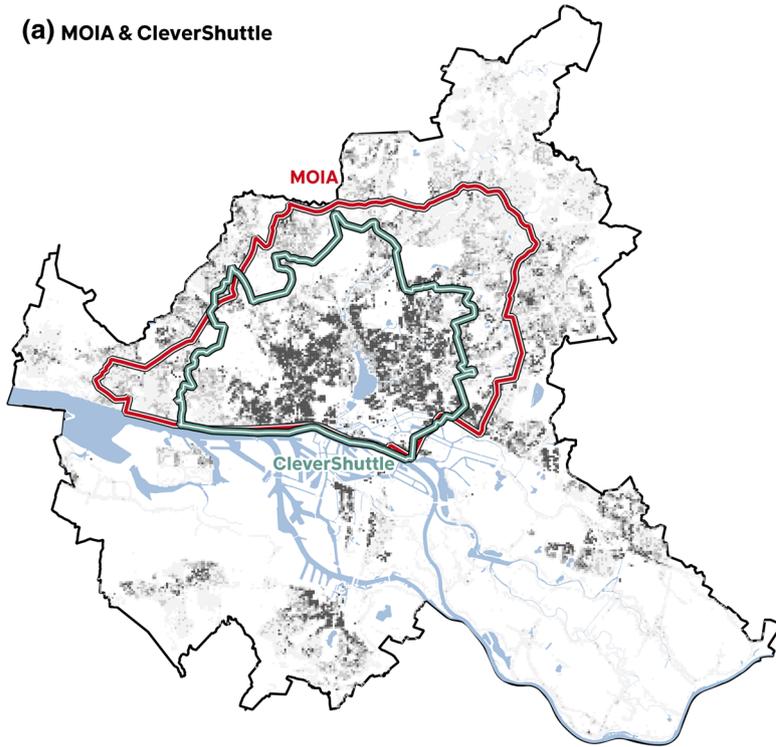
In terms of dwelling density, *ioki*'s indicator also deviates from the others: unlike the other ride-pooling schemes, *ioki* serves an area that is 21% less dense compared to the Hamburg settlement area. The larger schemes in turn cover areas that are much more densely populated (Table 1).

4 Discussion

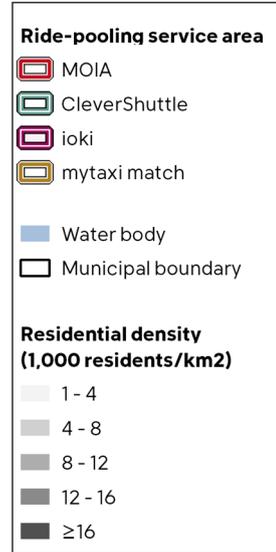
4.1 Ride-Pooling Does Not, Per Se, Deliver Substantial Utility for Low-Income Groups ...

The results fit into the well-replicated finding that the distribution of socio-economic characteristics is spatially

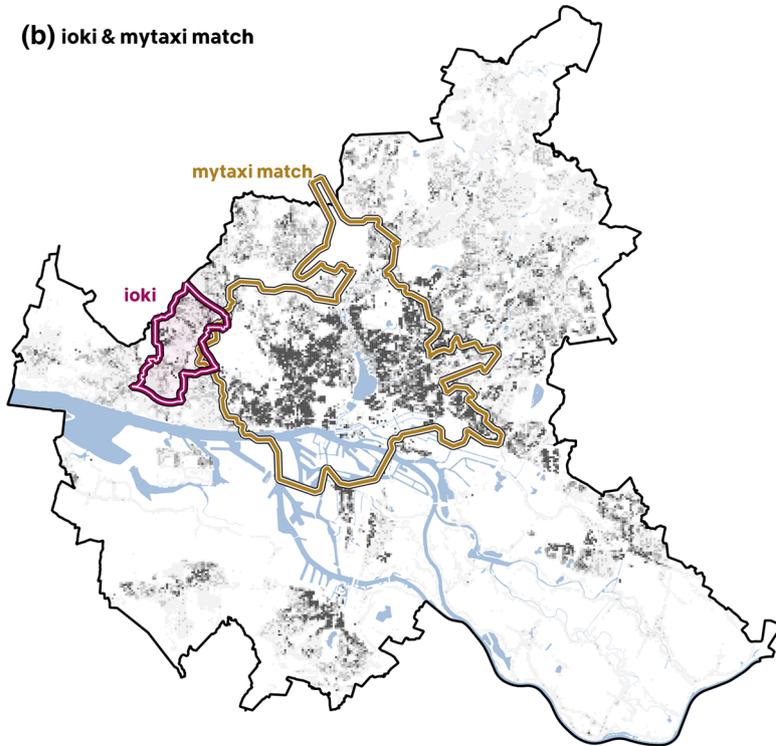
(a) MOIA & CleverShuttle



Ride-pooling schemes of Hamburg



(b) ioki & mytaxi match



Service areas: Derived from the operators' webpages, as of 05/2019
 | download dataset: [t1p.de/ridehh19](http://dx.doi.org/10.15480/336.2396.2)
 | DOI 10.15480/336.2396.2 | CC-BY-SA 4.0
 Water bodies: City of Hamburg / BSW, as of 02/2019 | [t1p.de/ata1](http://dx.doi.org/10.15480/336.2396.2) | [dl-de/by-2-0](http://dx.doi.org/10.15480/336.2396.2)
 Municipal boundary: City of Hamburg / LGV, as of 09/2019 | [t1p.de/he01](http://dx.doi.org/10.15480/336.2396.2) | [dl-de/by-2-0](http://dx.doi.org/10.15480/336.2396.2)
 National boundary: EuroGeographics, as of 2016 | [t1p.de/bi0c](http://dx.doi.org/10.15480/336.2396.2) | ©

Cities: Federal Agency for Cartography and Geodesy, as of 01/2020 | [t1p.de/973v](http://dx.doi.org/10.15480/336.2396.2) | [dl-de/by-2-0](http://dx.doi.org/10.15480/336.2396.2)



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Fig. 2 a Service areas of MOIA and CleverShuttle; b service areas of ioki and mytaxi match. For the GIS-based calculations I added a 300 m buffer, which is not depicted here

Ride-pooling availability and Public Transport coverage

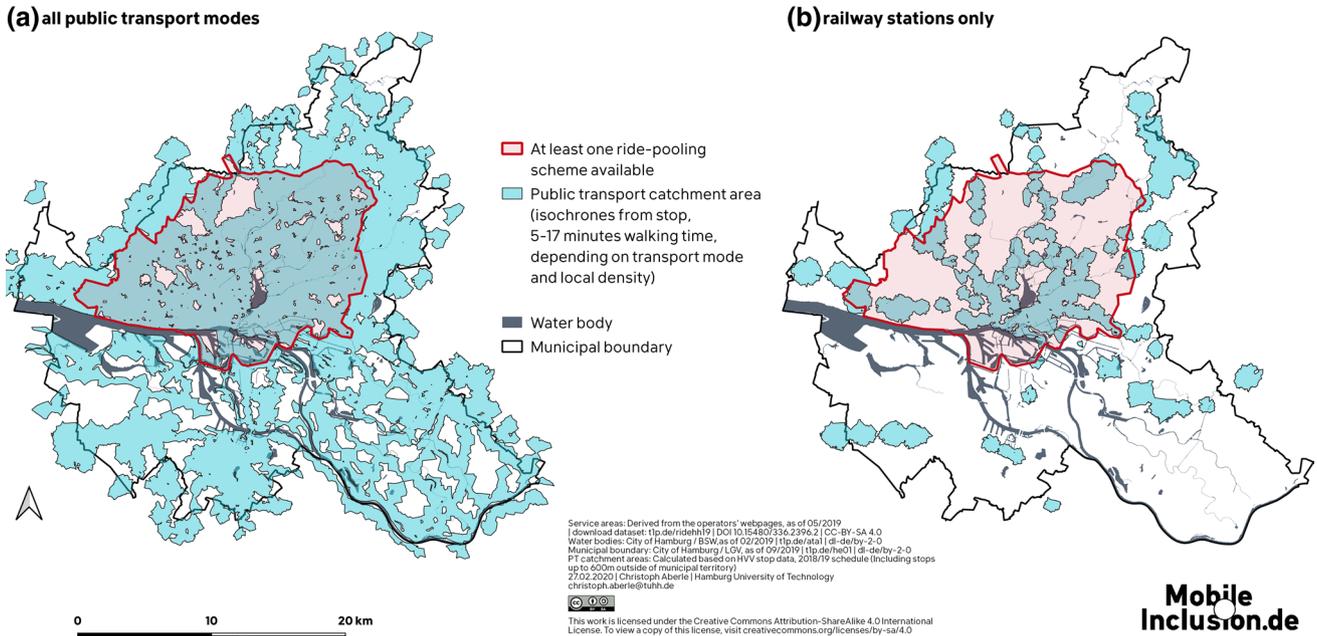


Fig. 3 Comparison of the area that is served by at least one ride-pooling scheme and the catchment area of public transport stations **a** for all public transport modes, **b** for railway only

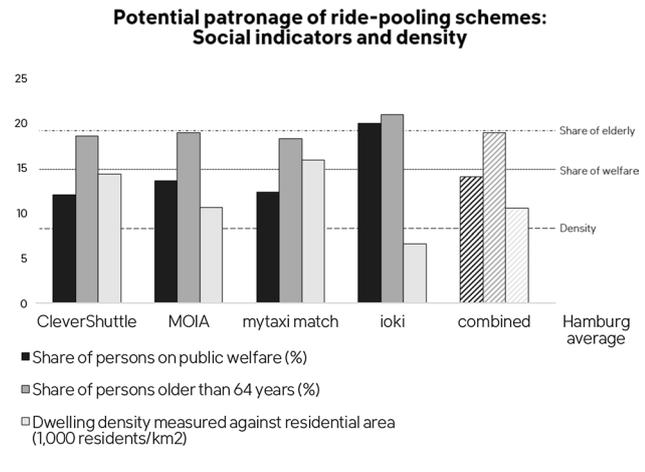


Fig. 4 Comparison of social indicators for four ride-pooling schemes in Hamburg

uneven (Florida 2015, 2017; Nightingale 2012). The concentration of urban income poverty in German agglomerations has been a persistent feature for decades, especially when it comes to large peripheral housing estates (Runge 2005). For MaaS providers, these peripheral districts apparently do not hold sufficient potential to run their schemes profitably. As a result, marginalised and 'poor' neighbourhoods are underserved by the large schemes. This is reflected in the indicators shown in Table 1: the

population served by the three large schemes is less poor and less old than the Hamburg average, while the service areas are more densely populated.

4.2 ... But When Governed Well, it Opens Opportunities for Everyone—including the Urban Poor

The exception is the *ioki* scheme, which was obliged by the public administration to operate in a remote area. The operation district has been lacking a decent railway connection for decades. Thus, *ioki* represents a case where a ride-pooling scheme makes a substantial difference to accessibility of (sub-)urban rail transport. As an evaluation of operations indicates, more than half of the *ioki* trips have indeed been used to reach railway stops and larger bus nodes (VHH 2019a).

The relatively high welfare share within *ioki*'s service area is tightly linked to its size, spatial location, and dwelling density. As Fig. 5 below shows, the Osdorfer Born housing estate lies in the centre of *ioki*'s service area, being home to 14.6% of the population served by the scheme while comprising only 5.6% of the service area. While covering a remote residential area, *ioki* does not include, e.g., the central business district (CBD). Meanwhile, the other schemes are large in size and cover the CBD and more 'affluent'

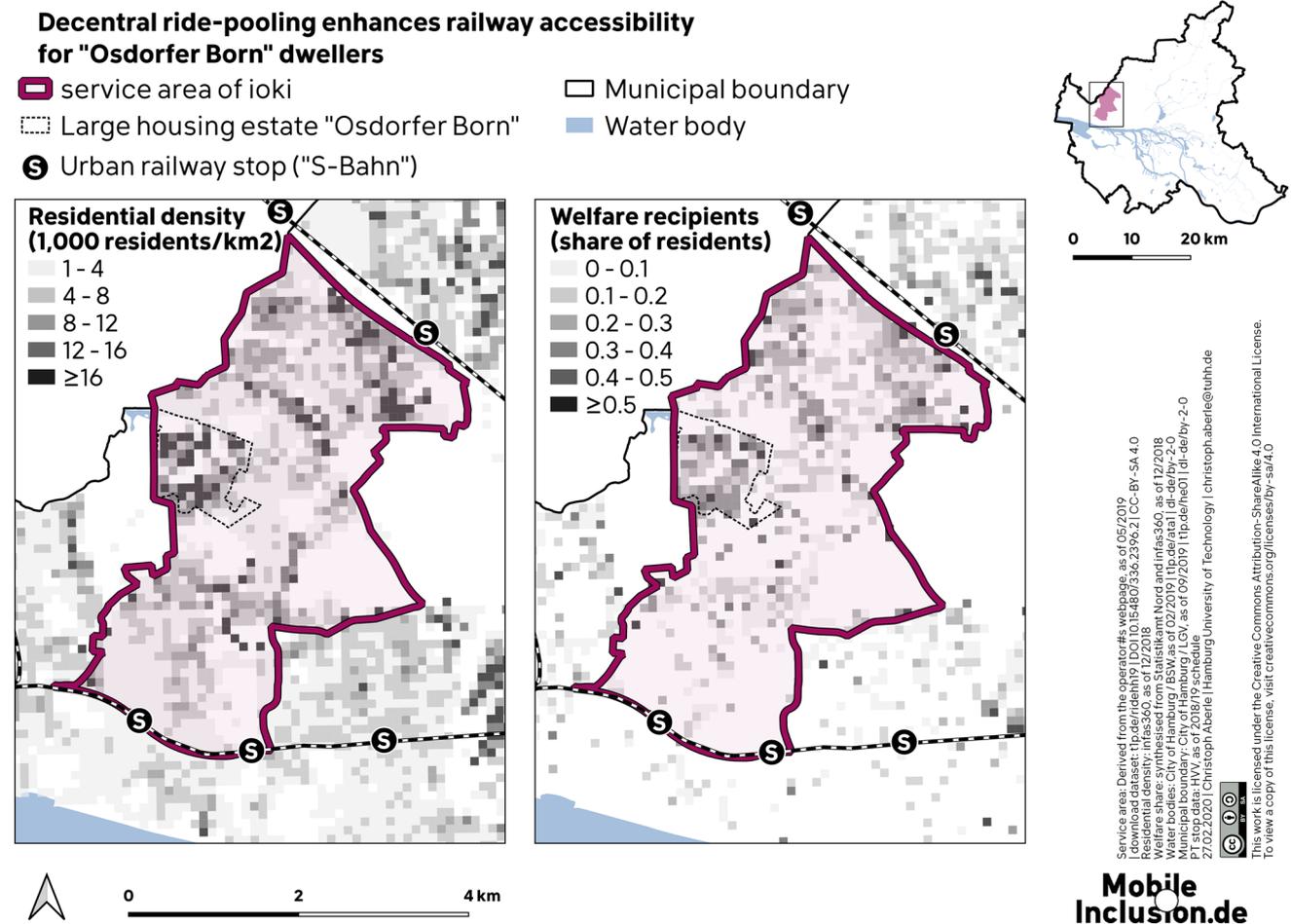


Fig. 5 Density and welfare distribution as well as railway access of residents within the *ioki* service area

districts as well as some 'poor' neighbourhoods (both indicated by welfare share). Overall, their socio-economic indicators might approximate the Hamburg average due to their spatial attributes rather than an agenda that lacks inclusivity. In other words, the three large ride-pooling schemes are—besides the fare—probably not less socially accessible than *ioki* per se. It might simply be that their extensions and spatial compositions cause their respective welfare shares to be lower. Similarly, *ioki*'s high coverage of urban poor is likely to be a well-intended result of the scheme's spatial attributes.

For some low-income inhabitants of *ioki*'s service area, as interview results of my colleague Stephan Daubitz reveal, the ride-pooling scheme indeed turns out to be useful:

"Four or five times [I've used *ioki*] when I went to the local food bank. Well, on the bus you wouldn't get [your groceries] carried [...] all the way home."

The statements concerning ride-pooling are manifold, ranging from appreciation (as quoted above) to suspicion

that the scheme is only a means to tranquilise locals who have been complaining about a lack of transport options for decades. As another interviewee puts it: "[*ioki* was] also [started] with the intention to sedate us" (Daubitz and Aberle 2020/excerpts of the presentation, translated by the author).

Since the focus of this paper lies on the GIS-based investigation of service areas, an in-depth discussion of welfare recipients' perception of ride-pooling schemes is beyond its scope (particularly, as MaaS was only a minor topic within the interviews). However, it is notable that all five interviewees who live in *ioki*'s service area know the scheme and instantly take up a stance on it. This contextual finding indicates that the respondents consider ride-pooling to be one option among many to meet situational mobility needs—which is, as explained in the introduction, one of the key qualities of MaaS.

5 Conclusion

New forms of urban mobility hold the potential to supplement existing transport services. Ride-pooling schemes can complement conventional services while being more flexible than traditional public transport and more affordable than taxi services.

In Hamburg, ride-pooling is only available north of the Elbe river. The schemes mainly cover areas that already have a decent level of public transport service, although they also partly serve areas that are not served by railways. Three of four experiments (i.e., *MOIA*, *CleverShuttle*, and *mytaxi match*) are being carried out in areas where the population is more densely distributed, younger and less depending on public welfare than the average population. An exception is presented by the *ioki* scheme on the western outskirts, which serves a remote district due to municipal requirement. From the urban poor's point of view, *ioki* offers an additional benefit that might be affordable even on a low income. The underlying public governance facilitates a MaaS scheme that is not cost-effective for the municipality/city but does address the urban poor.

This paper has highlighted the interrelation of ride-pooling services and the opportunity of access for economically deprived urbanites. By presenting a stance on inclusive urbanity, the results amend the debate around MaaS, which has so far mostly been focused on technical solutions. Further research can extend the analysis by considering more factors of deprivation risk such as, e.g., low purchasing power or gender-related restraints of mobility. Additionally, the methodology can be enhanced towards spatial statistics. Furthermore, the analysis of actual MaaS use, which is being carried out progressively by the operators, will be fruitful in this realm.

Whether, and under which conditions, MaaS will become an integral part of Hamburg's public transport remains to be seen once the experiments in preparation for the 2021 ITS Congress have ended. As this paper wants to point out, success is not to be measured only by the performance of the ride-pooling algorithms—but also by the question of who can partake in new mobility.

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Compliance with ethical standards

Conflict of interest None.

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