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EQUITY OF OUT-OF-HOME PARCEL DELIVERY SERVICES. CASE STUDY: POZNAŃ AGGLOMERATION

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Courier, express and parcel (CEP) services, similarly to postal ones, have started to be perceived as a basic necessity. Therefore, they have become of interest from an equity perspective. This article quantitatively assesses the out-of-home (OOH) delivery network in the Poznań agglomeration, with a focus on address points. The applied method allowed for more accurate analyses of spatial equity compared to the methods used in the previous studies. The results show that the Polish market for OOH services in 2024 was highly developed and competitive in the area studied. Nevertheless, spatial inequity was still observed, especially between the densely populated core of the agglomeration and the peripheral areas with lower population density. The analysis identified three groups of people with different access to services. In terms of accessibility, 76.8% of the agglomerations' inhabitants had access to at least two OOH networks, one of which was operated by InPost and was within walking distance. On the other hand, 3.8% of inhabitants had no access to OOH points, even if cycling was an option. This may suggest that intervention in the OOH services market is needed to improve situation of these people. On the other hand, the analysis shows that the situation is even worse in the traditional, subsidized postal services. The limitations of the methodology used prevented its successful application to assess other dimensions of equity. Further research is needed to obtain a complete picture that will take into consideration different stakeholder groups.

Keywords: Poznań agglomeration, out-of-home delivery network, equity analysis

1. INTRODUCTION

Courier, express and parcel (CEP) services are divided into Home Delivery (HD) services, in which a courier collects or delivers a parcel to the customer's door, and Out-of-Home (OOH) services, where a customer visits a point to send or collect

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a parcel. OOH points can be subdivided into Pick-Up-Drop-Off points (PUDO, also sometimes referred to in the literature as Collection and Delivery Points), where the service usually requires a human (seller) presence, and unmanned Automated Parcel Machines (APMs, also called Parcel Lockers), where the customer self-serves. Despite some differences in the operation of the two types of points, (Molin et al., 2022) suggest that, from the customers' perspective, they are treated more in terms of mutually competing substitutes than is the case with HD services – delivery to the recipient's door can be seen as an advantage on the one hand (e.g. not having to transport the parcel) and a disadvantage on the other (e.g. having to wait for a courier).

The growth of e-commerce in recent years has led to the development of a market for CEP services which, similarly to the postal services, have started to be perceived as a basic necessity (Keeling et al., 2021). Therefore, they have also become of interest from justice perspective. Justice can be considered at multiple levels (Curl et al., 2020). This article focuses on the distributive level, i.e., equity, which analyses the distribution of benefits and costs, and the degree that distribution is considered appropriate (Litman, 2022). Inequity occurs when the distribution of resources, exposures or outcomes is considered unfair. Therefore, analyses of this kind are crucial in assessing the equity of policies and interventions (Curl et al., 2020). Equity in transport and logistics systems can be considered in many dimensions (Curl et al., 2020; Lindsey et al., 2023; Litman, 2022). Three most commonly used categories, are spatial, horizontal and vertical. Spatial equity refers to the location from geographic perspective which may affect the accessibility to various services. Horizontal dimension of equity considers whether similar individuals are treated similarly. Two main categories of equity are considered here: a fair share of resources (“people should get what they pay for and pay for what they get”) and external costs (“polluter should pay for generated externalities”). Vertical equity considers how policy interventions affect groups considered as disadvantaged as they should receive favorable treatment. Three main categories are considered here: inclusivity which is related to needs and abilities (e.g. people with disabilities, seniors or with no broadband internet access), affordability which is related to income and costs as well as social justice which address structural inequities such as sexism or racism. There are many equity theories behind these categories, e.g.: basic needs, egalitarianism or libertarianism (Litman, 2024). Therefore, an intervention or policy equitable from one perspective may be inequitable from other. An intervention may also be considered equitable or inequitable depending on context-specific parameters (Lindsey et al., 2023). For example, public subsidies for investments may be perceived differently depending on their location, e.g., gentrified neighborhoods vs. neighborhoods in need of regeneration. Nevertheless, equity analyses provide a better understanding of the effects of policies or interventions.

This article evaluates the OOH network in the Poznań agglomeration, mainly from the perspective of spatial equity, which is particularly valuable for assessing

groups of people living in different areas – in this case, the core and periphery of the agglomeration. Some insights into affordability was also presented.

2. LITERATURE REVIEW

Equity analyses of OOH networks are a relatively new area of research. The author of the present study could not find a review article addressing this topic. However, a search in Google Scholar database showed the availability of relevant literature. (Keeling et al., 2021) analyzed the potential effects of introducing an agnostic parcel locker network on transit facility sites operated by TriMet (Portland, OR). Authors focused on inclusivity, considering disadvantage groups from the perspective of race, education, and internet access. (Schaefer, Figliozzi, 2021) also analyzed Portland area, focusing on the Amazon parcel locker network from both from spatial and vertical equity perspectives. Their analysis was undertaken on the census block groups, which are usually comprised of contiguous clusters of census blocks and contain 600-3000 people each. Additionally, there are studies addressing only the spatial distribution of OOH networks, which may be interesting from the equity perspective. (Morganti et al., 2014) analyzed four PUDO networks in Seine-et-Marne region of France, which at that time were much better developed than the APM network. The distribution of points was analyzed from the perspective of three categories of areas: urban, suburban, and rural. The authors found that network density was higher in urban areas compared to rural areas. From the car users perspective, 91% of the population had access to a PUDO point in less than 10 minutes. However, this was not the case for pedestrians, as the average distance to PUDO point in rural areas was 6 km. On the other hand, the study also found that a large number of PUDO points were located in walkable distances (i.e. 300-600 meters) from commuter railway stations. (Beckers, Verhetsel, 2021) analyzed seven OOH networks in Belgium, using 1 km² population grids and CORINE land cover map. They concluded that combining these networks into a single agnostic system would put 69% of the Belgian population within walking distance of OOH services (defined as a 1 km catchment area). At the same time, it would be possible to reduce the number of service points, as there was a 75% overlap of the existing catchment areas. (Lachapelle et al., 2018) discussed the location of APMs in the urbanized areas of South East Queensland, Australia. The authors conducted, among other assessments, a macro-level analysis, in which they observed that PUDO locations were, with a few exceptions, situated closer to population-weighted centroids than APMs. Finally, (Liu et al., 2019) analyzed the locations of OOH points in Stockholm County in relation to mobility and the corresponding external costs changes associated with the use of this network. They concluded that relocating 5% of OOH points from urban to suburban areas could reduce emissions from mobility related to this network by 22.5%.

The literature review shows two gaps. Firstly, most analyses were undertaken on the zonal level, e.g., census blocks or population grids, which often results in a loss of detail. In the present work, the address points (APs) level was considered. Secondly, the author has no knowledge of this type of analysis in Poland. However, according to (Last Mile Experts, 2024), Poland has the highest number of unique OOH locations in Europe. This is due to the fact that, until recently, there have been few restrictions on the location of OOH points in Poland, and there are many competing operators on the market. Additionally, the spatial structure of European cities, including their OOH networks, is often different from that of cities in other parts of the world.

3. METHODOLOGY

3.1. Distances from address points to nearest OOHs

In spatial equity analysis, it is important to define acceptable distances. In this article, these distances refer to the proximity between a given address point and the nearest OOH point. Distance decays curves show that friction of distance is non-linear, particularly in the case of active modes of transport, such as walking and cycling, where the desire to travel decreases relatively quickly with the distance covered.

On the other hand, using a car requires a driving license and is relatively expensive, which implies vertical equity considerations both from an inclusivity and affordability perspective (Litman, 2022). According to CBOS (Omyła-Rudzka, 2017), the driving license ownership rate in Poland is much lower than Poland's average for women, seniors and those with lower education levels.

In terms of age and gender differences, these results are also confirmed by studies carried out for the Sustainable Mobility Plan for the Poznań metropolitan area. The study found that 25% of women and 10% of men did not have a driving license. Similarly, in the case of age, 32% of individuals aged 65+ lacked a driving license, compared to 15% of those aged 18-64 years (Metropolia Poznań, 2023). Therefore, this paper considers access for walking and cycling.

(Weltevreden, 2008) observed that only when collection-and-delivery points are highly accessible, i.e., within a five-minute drive, they are more frequently chosen by consumers. Additionally, (Lemke et al., 2016) indicated that people prefer parcel lockers located close to their homes. Almost 15% of the study respondents indicated that they would use parcel lockers more often if their location was more convenient. The importance of proximity to the location of the OOH point was also noted in qualitative research by (Kedia et al., 2017). Also, research by (Molin et al., 2022) indicated the impact of distance on customers' perceived utility of OOH services. Their study found that this effect was slightly more pronounced for parcel lockers, possibly because PUDO points are often easier to integrate into daily routines and people often combining trips with shopping or other errands.

According to (Millward et al., 2013), the average walking distance to a mailbox (categorized as “for media or communications”) was 0.4 km, which was in general shorter than for other activities. (Iannaccone et al., 2021) recommended a maximum distance of 500 m from home or work to parcel lockers locations. On the other hand, (Hofer et al., 2020) estimated that the acceptable travel distance to a parcel locker, based on respondents’ preferred travel time, is 0.7 km for walking and 1.9 km for cycling. Similarly, (Keeling et al., 2021) estimated the impact range of parcel machines located at transit facility sites estimated at 0.8 km for walking and 2.1 km for cycling.

Due to uncertainties regarding the quality of data on the pedestrian road network outside the agglomeration center, and to simplify calculations, the Euclidean metric was used to determine distances in this study. This approach requires the use of circuitry indicators that estimate the difference between the actual travel distance and the straight-line distance. (Boeing, 2019) analyzed the circuitry of walking routes in 40 US cities, with index values ranging from 1.142 (Manhattan, NY) to 1.487 in Salem, MA. (Kisielewski, Skóra, 2016) referred to the values of 1.25-1.32. Based on these findings, a value of 1.3 was assumed for this study. Finally, the maximum acceptable travel distance values used in this paper were 0.5 km for walking and 1.5 km for cycling.

It is also important to consider the need for a buffer when conducting analyses on a selected area. In cases where distance calculations are required, the area containing OOH locations should be extended to prevent errors in measuring the distance to the nearest OOH point for address points located near the boundary. In this study, the author used 10 km buffer, as it was sufficient to ensure that none of the calculated distances were affected. However, this value should be determined on a case-by-case basis.

3.2. Data sources

Land cover and land use data for the Poznań functional urban area (FUA) was obtained from the Urban Atlas project. The land use is classified into 17 urban and 10 rural categories. The Minimum Mapping Unit depends on class, ranging from 0.25 to 1 ha. It is worth noting that there are 5 different classes related to urban fabric (classification based on building density) but only one class encompasses industrial, commercial, public, military and private areas. The last dataset available for Poznań FUA dates back to 2018.

The National Register of Boundaries (PRG) was used to obtain administrative borders of gminas (Polish municipalities), as well as the locations of address points and their assignment to different villages and towns (as October 2024). Information about population in gminas (2023) and median monthly salaries in the national economy (March 2024) were obtained from Statistics Poland. These datasets made it possible, among other things, to estimate the number of inhabitants (including seniors) assigned to a given address point.

Finally, the locations of OOH infrastructure were determined through a review of publicly available data on the internet. The infrastructure of nine major CEP service providers was identified on the analyzed area, including Allegro, DHL, DPD, FedEx, GLS, InPost, Orlen, Poczta Polska, and UPS.

It is worth noting that Poczta Polska is also a Polish designated postal operator. Not all of its locations handle typical CEP services (called ‘Pocztex’ for this operator), allowing only the mailing of traditional parcels as part of the postal offer – a service called ‘postal parcel’. This service is not integrated with e-commerce shops. Moreover, many of the OOH locations serving Pocztex parcels do not support the mailing of traditional letters. Therefore, these networks were treated separately in this study. The OOH network included points handling the Pocztex service, while the network offering postal services was used for comparison.

3.3. Data aggregation

In the Polish OOH network, there are cases where there is a high accumulation of APM points in close proximity, and some PUDO points serve parcels for multiple operators. The coordinates of these points may be published by operators with minor discrepancies. Therefore, the DBSCAN spatial clustering method was used to estimate the number of unique OOH points. It was assumed that OOH points belong to a unique cluster if their mutual distance did not exceed 25 meters.

Some analyses were also conducted at an aggregated scale, i.e., from address points to the settlement or gmina level. Standardized H3 grid was chosen for estimating the spatial accessibility of the OOH network and for visualization purposes, with resolution 8 being used.

4. AREA OF STUDY

This article analyses a part of Poznań functional urban area (fig. 1), covering a total of 19 gminas. Poznań serves as the agglomeration core, while the peripheral gminas include Czerwonak, Dopiewo, Kleszczewo, Komorniki, Kórnik, Luboń, Mosina, Puszczykowo, Rokietnica, Suchy Las, Swarzędz, Tarnowo Podgórne, Brodnica, Czempin, Kostrzyn, Murowana Goślina, Pobiedziska, and Stęszew. The first twelve gminas are classified into inner periphery, while the last six to outer periphery.



Fig. 1. Analyzed gminas. In brackets, the number of villages and towns in gmina is shown.
L. – Luboń, P. – Puszczykowo. Blue color – urban fabric areas

Basic characteristics of the area are presented in table 1. The analyzed gminas have a total population of 990,000, of which 54.4% live in Poznań, 36.5% in the inner periphery, and 9.1% in the outer periphery. The highest density of population per address point (AP) also occurs in Poznań (8.65 person/AP). It is related to the higher number of multi-apartment buildings to which a single address point is assigned. The area of analysis is 2,309 km². The highest median monthly salary is in the inner periphery area – on average 7,302 PLN (ranging from 6,489 PLN in Mosina to 7,847

PLN in Dopiewo), while the lowest in the outer periphery – 6,309 PLN (ranging from 5,600 PLN in Brodnica to 6,997 PLN in Kostrzyn). Both inner and outer periphery areas consist of about 200 different towns and villages. In case of the outer periphery area, the villages are in general smaller than in other parts of the agglomeration – 150 of them contain less than 100 address points. Also, the proportion of urban fabric area is the lowest in the outer periphery.

Table 1. Basic characteristics of the study area

Characteristic	Core	Inner periphery	Outer periphery	Total
Population	538,439	361,510	90,443	990,392
Area [km ²]	261.9	1,117.7	929.7	2,309.3
No. of address points (AP)	62,259	101,589	27,687	191,575
Avg. median monthly salary [PLN]	7,048	7,302	6,309	6,975
Avg. urban fabric area [%]	20.7	12.9	3.0	10.2
No. of town/villages	1	188	202	391
No. of town/villages (>99 AP)	1	125	52	178
No. of town/villages (>199 AP)	1	100	23	124

In this paper, the urban-rural divide was not considered, as it is distorted by urban sprawl in the Poznań agglomeration. The study area includes, for example, the village of Koziegłowy, which has a population of over 10,000, but is formally part of the rural Suchy Las gmina.

5. RESULTS

In the study area, the existence of 2,431 unique OOH point locations was estimated (fig. 2). In comparison, the report by (Last Mile Experts, 2024) estimates the existence of nearly 80,000 such points across the country. 61.7% (1,499) of unique clusters are located in Poznań. In the other gminas, the number of OOH locations is between 6 (Brodnica) and 143 (Swarzędz). There were 1,159 unique locations with only APMs and 942 with only PUDOs. 1,541 unique locations consist only one OOH point. On the other hand, in Kamionki (gmina Kórnik), in and nearby the shopping gallery, on a total area of approximately 800 m², there were a total of 13 OOH points (6 APMs and 7 PUDOs), which served the parcels of 7 operators.

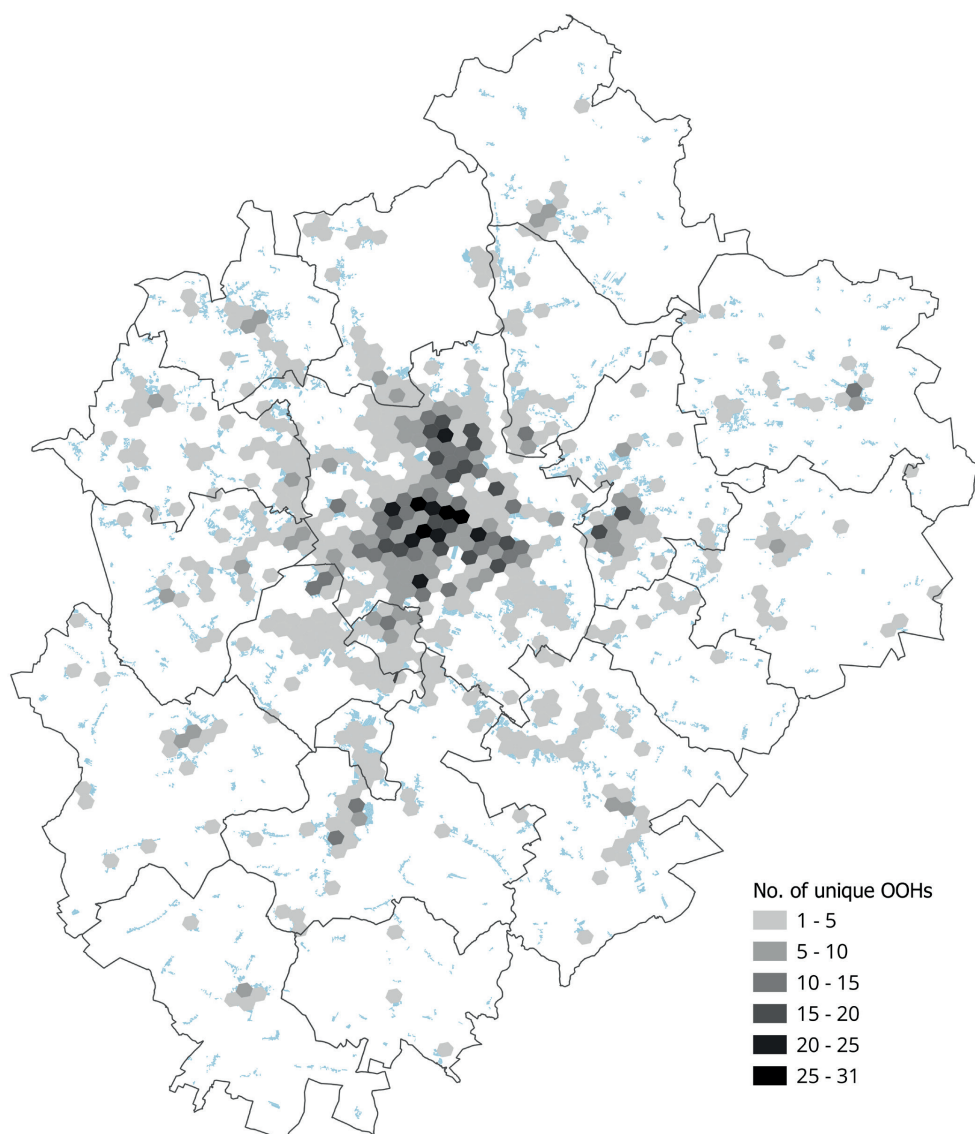


Fig. 2. Spatial distribution of unique OOH locations

Taking into account that some unique OOH points serve parcels from many operators, the number of locations by operator is higher and amounts to 4,326, of which 61.3% are located in Poznań. An additional 782 OOH points were located in the 10 km buffer zone surrounding the study area.

Table 2. Number of OOH points in the study area by analyzed operators

Operator	No. of APMs	No. of PUDOs	Total
Allegro	215	10	225
DHL	63	626	689
DPD	213	728	941
FedEx	–	145	145
GLS	–	156	156
InPost	1,077	–	1,077
Orlen	174	171	345
Poczta Polska	14	664	678
UPS	–	70	70
Total	1,756	2,570	4,326

In the analyzed area, there are 149 Poczta Polska offices, of which 139 of also handle Pocztex deliveries. The remaining 10 offices are not included in table 2. Additionally, this network includes 525 PUDO points, which operate as partner locations.

Table 3 shows the basic characteristics of the accessibility of gminas, towns, and villages to the OOH network. In the Poznań agglomeration, there are an average of 19.58 unique OOH locations for every 10,000 inhabitants. This value, as along with the density of OOH locations in urban areas, is higher in Poznań than in the outer periphery. The average number of OOH operators available in a unique location is around 1.8 across all parts of the agglomeration. The higher number of PUDOs compared to APMs is particularly visible in outer periphery. Out of 391 settlements, 166 contain at least one address point located within 500 meters of an OOH point. At the same time, accessibility is clearly lower in the case of settlements located in the outer periphery, where only 52 out of 202 settlements meet this condition. Accessibility by bike is slightly better, but again, half of the settlements in the outer periphery do not have access to OOH. This accessibility, however, is significantly higher in settlements with a larger number of address points. The exceptions containing more than 200 address points and yet not having access to OOH even by bicycle are: Kamińsko (gmina Murowana Goślina), Konarskie (Kórnik) as well as Radzewice and Sowinki (Mosina). It should be noted, however, that access to postal services in the analyzed area is much worse than access to courier services. Only 163 (0.008‰) of address points (located mainly in the Strykowo village) have walking-distance access to post services and are located at least 100 meters closer to a postal service point than to a courier service point. In the case of bicycle coverage, this number increases to 351 APs (again mainly located in Strykowo).

Due to the fact that the nature of the services differs slightly between APM and PUDO points, and that the OOH network operators compete with each other in terms of price and quality (e.g. maximum time allowed for parcel collection), a separate analysis was also made for APM and PUDO networks, as well as for the OOH network of the largest operator (InPost) and the other operators. The results indicate that about 30% of the settlements had simultaneous access to both types of OOH services. The same percentage of the settlements had access to both the InPost network and at least one of its competitors.

Table 3. Basic characteristics of the accessibility of gminas and settlements to the OOH network

Characteristic	Core	Inner periphery	Outer periphery	Total
Avg. No. unique OOH locations / 10k inh.	27.84	20.60	16.16	19.58
Avg. unique OOH locat. / 1 km ² of urban fabric	27.64	7.75	5.07	7.95
Avg. No. of operators in unique OOH	1.77	1.82	1.87	1.83
PUDO/APM Ratio	1.41	1.49	2.25	1.72
[%] of towns/villages with walk access to OOH	100	60	26	42
-incl. towns/villages >99 Address Points (AP)		82	67	78
-incl. towns/villages >199 AP		90	87	90
[%] of towns/villages with walk access to Post office	100	22	5	14
[%] of towns/villages with cycling access to OOH	100	79	50	64
-incl. towns/villages >99 Address Points (AP)		94	88	93
-incl. towns/villages >199 AP		97	96	97
[%] of towns/villages with cycling access to Post office	100	42	19	30
[%] of towns/villages with walk access to APM	100	54	22	37
[%] of towns/villages with walk access to PUDO	100	53	18	35
[%] of towns/villages with walk access to both APM and PUDO	100	46	14	30
[%] of towns/villages with walk access to InPost operator	100	50	22	36
[%] of town/villages with walk access to other operators	100	54	18	36
[%] of town/villages with walk access to both InPost and other operators	100	44	14	29

Figure 3 shows the spatial distribution of address points accessibility to the OOH network. Over an area of about 35% of the agglomeration, access is insufficient for active modes of transport. In the worst case, the distance from the address point to the nearest OOH was 5.9 km. In the case of the APM network, it was 7.2 km and for the PUDO network – 9.1 km.

Table 4 shows the basic characteristics of OOH accessibility at the address point level. A total of 73% of address points are within 500 meters of the OOH, while 93% fall within a 1,500 meters radius. Moreover, 87% of address points have bicycle access to both APMs and PUDOs, as well as to networks operated by InPost and other operators. It is worth noting that address points without access to the OOH network by active transport are usually located in areas with lower population density. Therefore, it can be estimated that the lack of pedestrian access to the OOH network affected about 137,000 (~14%), and the lack of access by bicycle about 38,000 (~4%) inhabitants of the agglomeration.

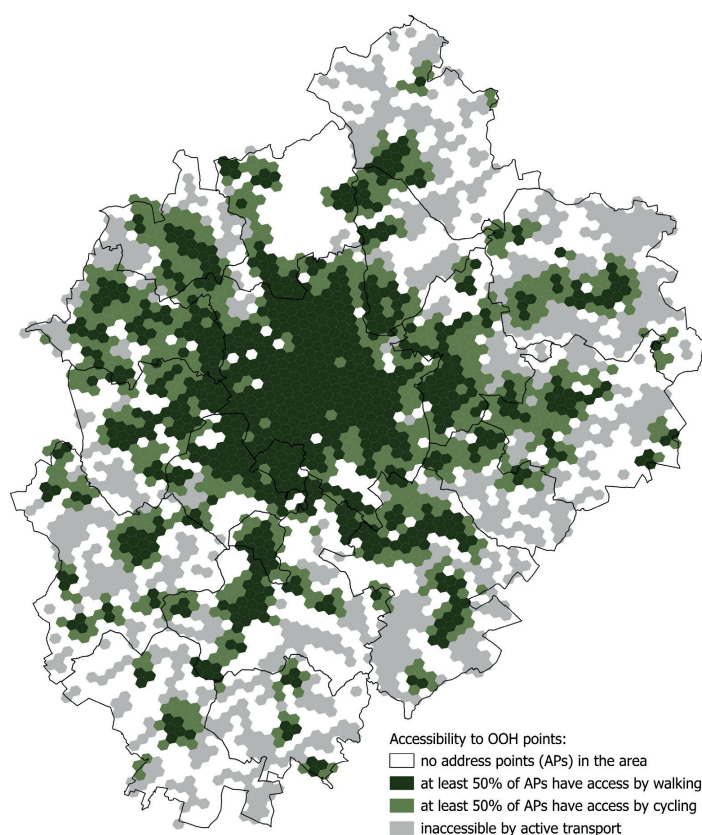


Fig. 3. Spatial accessibility to OOH network in Poznań agglomeration

Table 4. Basic characteristics of accessibility of Address Points (AP) to OOH network in Poznań agglomeration

Characteristic	Core	Inner periphery	Outer periphery	Total
[%] of APs with walk access to OOH	91	68	49	73
[%] of APs with walk access to APM	90	61	44	68
[%] of APs with walk access to PUDO	81	54	38	61
[%] of APS with walk access to both APM & PUDO	80	47	33	56
[%] of APs with cycling access to OOH	100	93	76	93
[%] of APs with cycling access to APM	100	91	73	91
[%] of APs with cycling access to PUDO	99	89	69	89
[%] of APs with cycling access to both APM & PUDO	99	86	65	87
[%] of APs with cycling access to Post office	92	59	48	68
[%] of APs with cycling access to InPost	100	90	73	91
[%] of APs with cycling access to other operators	99	89	69	89
[%] of APs with cycling access to both InPost and other operators	99	86	66	87

Figure 4 shows how often the OOH point from a given operator is the closest to the address point, considering only address points with bicycle accessibility. The main operator is InPost (42% of APs), which is visible especially in the outer periphery (49% of APs). The second largest share operator is DPD (18%), and the third one is Poczta Polska (11%, with slightly better visibility in the inner periphery). The next three OOH networks have more varied accessibility depending on the analyzed part of the agglomeration. The Allegro and Orlen networks are relatively close to address points mainly in Poznań (11% and 12% respectively), while the DHL network is more accessible in the agglomeration core and inner periphery. In the outer periphery, the FedEx network is slightly more visible – 5% versus 2% in the entire agglomeration. Analyses conducted at the walking access level and for all address points yielded similar results.

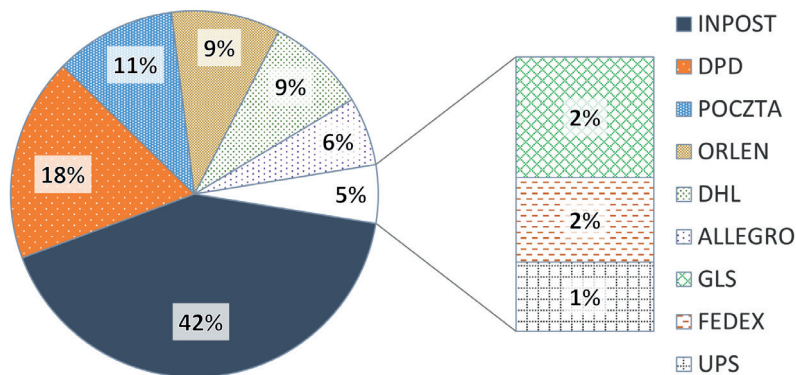


Fig. 4. The operator of the nearest OOH accessible by bicycle is... [% of APs]

Table 5 shows the location of address and OOH points according to land use. Both types of points are frequently located in dense urban fabric areas, i.e., with at least 50% of the sealing layer (SL) area. In addition, OOH points are often located in commercial sites and on land associated to transport infrastructure. On contrary, APs are more commonly located on discontinuous urban fabric areas (SL <50%).

Table 5. Address points (AP) and OOH points locations by land use

Land use / land cover	Total [%]		Core [%]		Inner periphery [%]		Outer periphery [%]	
	AP	OOH	AP	OOH	AP	OOH	AP	OOH
Continuous urban fabric (SL > 80%)	23	33	31	38	19	24	17	26
Discontinuous dense urban fabric (SL 50% – 80%)	41	25	47	22	39	31	35	31
Industrial, commercial, public, military and private units	6	25	8	28	5	22	5	15
Roads, railways & airports and associated land	1	7	1	8	1	4	1	10
Green areas (incl. sports and leisure facilities)	13	6	4	3	16	10	21	13
Discontinuous urban fabric (SL < 50%) & isolated structures	14	3	7	1	18	8	20	4
Construction sites, land without current use and others	2	1	1	1	2	1	1	1

More detailed analyses, which distinguished OOH points into APM and PUDO, indicated that slightly more (37% to 27% of all locations) PUDO points were located

in the highest density areas ($SL > 80\%$). In contrast, APMs were relatively more frequently located in lower density areas ($SL\ 50\%-80\%$) – 30% versus 22% of all locations. The density of development in the vicinity of an address point was also correlated with its accessibility to the OOH network. In particular, APs located in discontinuous low-density urban fabric ($SL\ 10\%-30\%$) in the outer peripheries were more likely to lack access. Only 27% of these APs had pedestrian access, while 46% had bicycle access. In comparison, for the continuous urban fabric ($SL > 80\%$), more than 70% of address points had walking access, and nearly 90% had bicycle access. In the core area, virtually all address points in this category had walking accessibility. It is worth noting that some address points were located in green areas, such as pastures. This was due not only to the generalizations applied in the Urban Atlas project, but also to the development of buildings in the agglomeration that did not exist in 2018. It is worth noting (fig. 5) that some OOH locations are also located in such areas. This suggests that services of this type appear either simultaneously with new residential developments or shortly afterwards.

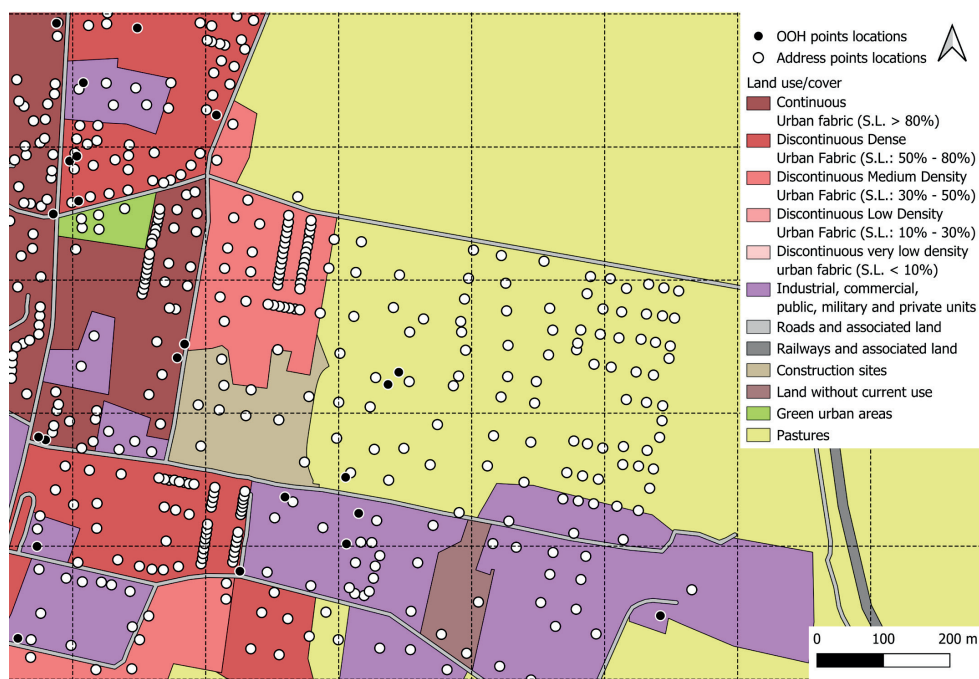


Fig. 5. Example of new residential development (after 2018) – Naramowice area in Poznań. The areas classified as pastures include both address points and OOH locations

The location decisions of OOH operators seem to be independent of median salaries in a given gmina within the analyzed area (fig. 6). A low density of unique OOH locations per 10,000 inhabitants (12-14) was found both in gminas with the

lowest median salaries (Brodnica, Czempin) and in Kleszczewo (gmina with the fourth highest median salary in the analyzed set). Similarly, the density of unique OOHs is above 20 in both Stęszew (third lowest median salary) and Dopiewo (highest median salary).

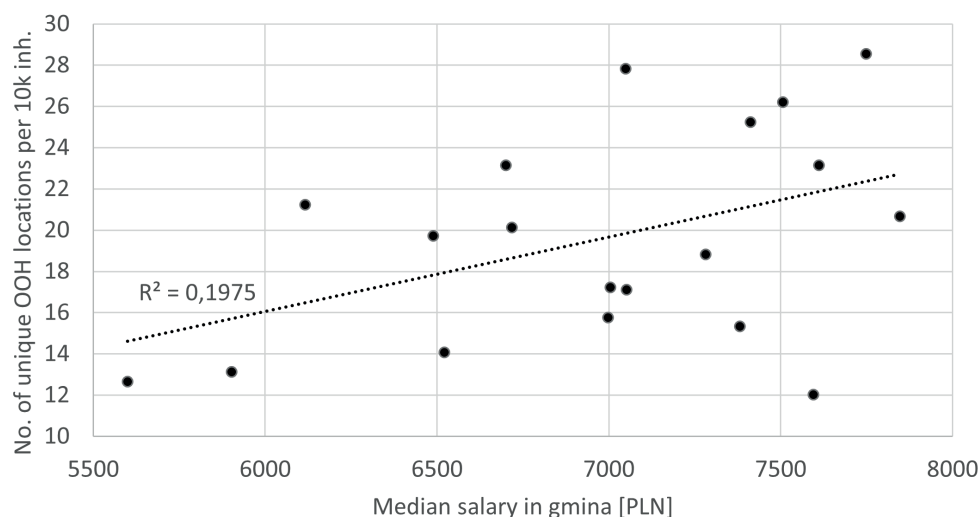


Fig. 6. Comparison of the location density of unique OOH points with the median salary in gminas

6. DISCUSSION

The analysis conducted in this study confirmed observations in the literature that OOH points are more commonly located in areas with dense housing. A building density of less than 50% sealing layer is a predictor of the absence of OOH location, regardless of the part of the agglomeration considered. Thus, address points or settlements characterized by this form of development have significantly worse access to the OOH network. Resulting inequity applies to the residents of 7% of address points (ca. 38,000 inhabitants, i.e. 3.8% of population) located in 35% of the agglomeration area. In general, these residents need a car to access the OOH network. It is possible that some may gain access using public transport, but at the time of preparing this article, the quality of passenger information in the area was insufficient to support this kind of analysis. Another alternative for these residents are Home Delivery services. However, such services are often more expensive or require one-time purchases for a larger amount of money in the case of subscription-based access. Also, HD services require customers to wait for a courier or compromise on privacy and security of the delivery if the parcel is left at a neighbor's house or in front of the customer's home.

On the other hand, residents of around 57% of the address points (ca. 760,000 inhabitants, i.e. ca. 76.8% of agglomeration's population) in about 30% of towns and villages have walking access to both APM and PUDO points, as well as to the OOH network of the leading OOH operator and at least one competitor. This allows them to make choices based on price and quality of service. However, this applies to ca. 80% of address points located in Poznań, but only to ca. 50% of address points in the inner periphery, and to ca. 33% in the outer periphery. The remaining population, i.e. approximately 192,000 (19.4%) people living in 36% of the address points, has only basic access to OOH services. This may suggest that the current Poland's approach of few restrictions on the competitiveness of services and on the ability to locate OOH points does not provide a sufficient level of equity. However, accessibility to points which offer traditional postal services is significantly worse than accessibility to the OOH network, despite the fact that postal services are subsidized to offer better accessibility. On the one hand, this is the effect of the decreasing importance of traditional postal services due to the digitalization of information exchange and trade. On the other hand, according to (Eurostat, 2024) data, 13.6% of people in Poland did not use the internet in 2023. In addition, 3.8% of Poles had no digital skills, while another 38.3% had digital skills below the basic level. Seniors, in particular, are a group that may simultaneously lack the ability to travel by car and sufficient digital skills. In the Poznań agglomeration, about 90,000 people in the post-working age live beyond walking distance to a post office. Therefore, it may be worth to consider to develop other methods of providing such services to people who are digitally excluded and lack viable transport options.

The method of assessing accessibility at address point level used in this study demonstrated its effectiveness in evaluating equity with a high level of detail. The study identified three groups of residents differentiated in this respect. This number could easily be increased by introducing additional thresholds related to the distance to the OOH point or by differentiating the assessment according to the mode of transport used. However there are also some limitations of this approach. One of them is data unavailability at sufficient resolution. This applies, in particular, to characteristics such as income levels, which are virtually impossible to obtain and analyze at address point level due to privacy considerations. As a result, no clear inequities from affordability perspective were observed at the gmina level. However, access to a higher resolution of the data on income would perhaps allow the identification of groups that are more vulnerable to a lack of OOH services, given the differences in service availability (density).

A second limitation of using address points for assessment is the inability of calculating their area, as only coordinate data is available. Therefore, supplementary methods are needed for assessing the spatial extent of accessibility.

The next limitation of the proposed approach is that it relies on objective measures of accessibility, as people's subjective sense of accessibility may be different due to the potentially different marketing effectiveness of different service

providers and the associated lack of consumer knowledge of the existence of some alternatives. This issue was not explored in this work. The impact of factors such as health and the resulting ability to move was also not analyzed. With that said, it is worth noting that people with limited mobility had access to Home Delivery services in the study area. However, equity analysis in this area could be expanded. For example, in 2021, concerns were raised in Poland regarding the accessibility of parcel lockers for people with disabilities or those of short stature who could not reach higher-placed compartments. As a result, service providers have proposed changes to their applications to determine preferences in this regard (e.g., *Business Insider Polska*, 2021). However, a more thorough analysis may still be required from the perspective of, for example, meeting the ISO 21542 standard, or analyzing the accessibility of smartphone applications, especially in the case of APMs that exclusively communicate with the customer via this channel.

Further research may be also needed to assess potential delays in lunching OOH services in newly developed residential areas. Results of this study suggest that such delays may be non-existent. However, the research was not configured to analyze this issue in detail. Finally, it should be noted that increasing density of OOH points increases the external costs associated with them. For example, from the customer perspective, security is important (e.g. Kedia et al., 2017), and can be increased by the installation of video surveillance. On the other hand, among those living in the vicinity of an OOH service location, this may cause some privacy concerns (e.g. wiadomoscihandlowe.pl, 2024). Other external costs associated with OOH services include nighttime noise, visual intrusion (also light at night), and parking difficulties in the surrounding area. Therefore, for the evaluation of policies governing OOH network development, it is important to conduct comprehensive analyses (including emissivity) to ensure that interventions take into account various trade-offs.

7. CONCLUSIONS

In 2024, the Polish market of OOH services in the Poznań agglomeration was highly developed and competitive. Accessibility to OOH services was much better than in case of subsidized postal services. Despite that, spatial inequities were still observed within the analyzed area. The method used in the study enabled three different groups of residents to be identified in terms of spatial access to OOH services. However, the results from affordability perspective were not clear. To fully assess the impact of policy decisions on the possible location of OOH points, further equity analyses, e.g., from an external cost perspective, are recommended.

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SPRAWIEDLIWOŚĆ USŁUG TYPU OUT-OF-HOME W DOSTAWACH PACZEK. STUDIUM PRZYPADKU: AGLOMERACJA POZNAŃSKA

Streszczenie

Usługi kurierskie, ekspresowe i paczkowe (KEP), podobnie jak usługi pocztowe, zaczęły być postrzegane jako usługi podstawowe. W związku z tym stały się one interesujące z perspektywy oceny sprawiedliwości dostępu do nich. W niniejszym artykule dokonano



ilościowej oceny sieci dostaw poza domem (OOH) w aglomeracji poznańskiej na poziomie punktów adresowych. Zastosowana metoda pozwoliła na przeprowadzenie bardziej dokładnych analiz przestrzennego wymiaru sprawiedliwości względem metod stosowanych w poprzednich badaniach. Wyniki pokazują, że polski rynek usług OOH w 2024 r. na badanym obszarze był wysoko rozwinięty i konkurencyjny. Mimo to zróżnicowane przestrzenne w dostępności do usług ciągle było widoczne, szczególnie pomiędzy gęsto zaludnionym rdzeniem aglomeracji a peryferiami cechującymi się mniejszą gęstością. Analiza wyłoniła trzy grupy osób mających różny dostęp do usług. 76,8% mieszkańców aglomeracji miało w odległości krótkiego spaceru dostęp do co najmniej dwóch sieci OOH, w tym jednej obsługiwanej przez InPost. 3,8% mieszkańców nie miało dostępu do punktów OOH, nawet biorąc pod uwagę jazdę na rowerze. Może to sugerować, że potrzebna jest interwencja na rynku usług OOH, aby poprawić sytuację tych osób. Z drugiej strony analiza pokazała, że w przypadku tradycyjnych, subsydiowanych usług pocztowych sytuacja jest jeszcze gorsza. Ograniczenia zastosowanej metody uniemożliwiły jej skuteczne zastosowanie do oceny innych wymiarów sprawiedliwości. Dalsze badania są niezbędne w celu otrzymania pełnego obrazu sytuacji, który uwzględniałby różnych interesariuszy.

Słowa kluczowe: sieć dostaw out-of-home, analiza sprawiedliwości, aglomeracja poznańska