

**Kateryna Kravchenko**

PhD (Geography), Associate Professor, Kostyantyn Niemets Department of Human Geography and Regional Studies,  
V.N. Karazin Kharkiv National University,  
Svobody Sq., 4, Kharkiv, 61022, Ukraine

e-mail: [kateryna.kravchenko@karazin.ua](mailto:kateryna.kravchenko@karazin.ua), <https://orcid.org/0000-0003-4654-3185>

**Yevhen Shpak**

PhD Student, Kostyantyn Niemets Department of Human Geography and Regional Studies,  
V.N. Karazin Kharkiv National University,  
Svobody Sq., 4, Kharkiv, 61022, Ukraine

e-mail: [yevhenstarling@gmail.com](mailto:yevhenstarling@gmail.com), <https://orcid.org/0009-0000-7035-0389>

**Yevhen Khabusev**

PhD Student, Kostyantyn Niemets Department of Human Geography and Regional Studies,  
V.N. Karazin Kharkiv National University,  
Svobody Sq., 4, Kharkiv, 61022, Ukraine

e-mail: [evgenijh7@gmail.com](mailto:evgenijh7@gmail.com), <https://orcid.org/0009-0005-7407-0364>

## HUMAN-GEOGRAPHICAL FEATURES OF TRANSPORT ACCESSIBILITY RESEARCH OF PRE-SCHOOL AND SECONDARY EDUCATION INSTITUTIONS IN THE CITIES OF KHARKIV AND WARSAW

An efficient transport system is one of the important elements of an economically developed city. The quality of transport infrastructure and the provision of logistics services primarily contribute to the accessibility or ease with which people can reach their main destinations, such as work, health care and education, using a particular mode of transport, or a combination of these. In the article, a socio-geographical analysis of transport accessibility of preschool and general educational institutions in Kharkiv and Warsaw was carried out. Features of the methodology of transport accessibility research using geoinformation systems QGIS 3.16 and ArcGis 10.7 are presented based on OpenStreetMap data. On the basis of a spatial GIS analysis of the placement of preschool and secondary education institutions, buffer zones were built, which cover the territory in a 500-meter (approximately 5-minute) accessibility zone.

It was established that the cities of Kharkiv and Warsaw have a well-developed transport infrastructure, in the city of Kharkiv the structure of passenger traffic by type of transport is dominated by the subway, in the city of Warsaw - bus transport. A comparative analysis of the accessibility of preschool educational institutions by all types of public transport in Kharkiv and Warsaw showed that, in general, the share of the number of institutions located in buffer zones is practically the same by type of transport. The number of preschool educational institutions in Warsaw is 3.5 times more than in Kharkiv. In the course of the study of the transport accessibility of general educational institutions by all types of public transport in Kharkiv and Warsaw, it was established that, in general, by means of transport, the share of institutions located in buffer zones is almost equal, the number of secondary educational institutions in Warsaw is almost twice as large as in Kharkiv. The number of educational institutions located in buffer zones is almost 90%: out of 215 schools, 213 are located in public transport buffer zones. The majority of educational institutions (99%) in Warsaw are located in the buffer zones of bus routes, which indicates the wide coverage of this mode of transport. The metro provides access to 27% of the city's schools. A significant part of schools (51%) in Warsaw is located in the buffer zones of tram routes, which increases the accessibility of educational institutions.

In general, the cities of Kharkiv and Warsaw are characterized by a fairly high level of transport accessibility to educational infrastructure, since more than 99% of educational institutions are located within the buffer zones of public transport, which confirms the effectiveness of the transport infrastructure of the cities in providing access to preschool and secondary education institutions.

**Keywords:** *transport infrastructure, transport accessibility, educational institutions, buffer zones, public transport.*

**In cites:** Kravchenko, K., Shpak, Ye., Khabusev, Ye. (2024). Socio-geographic features of the study of transport accessibility of institutions of the social sphere in the cities of Kharkiv and Warsaw. *Journal of Human Geography*, 36, 36-48. <https://doi.org/10.26565/2076-1333-2024-36-03>

**Formulation of the problem.** Currently, the cities of the world and their population are growing extremely fast, which requires constant improvement and development of social infrastructure, in particular transport. Therefore, transport is an extremely important component of urban infrastructure, the development of the social and industrial sphere depends to a large extent on its optimal functioning. It is a complex element of the

economic system of the city of strategic importance, which provides transportation of passengers and goods, connection of territories. By its nature, transport is a complex system consisting of transport routes and vehicles, the optimal use of which is ensured by transport logistics. An important branch in the service sector is transport, the main purpose of which is to ensure territorial interconnections [2].

The level of transport development and transport accessibility are indicators of the level of development of all subsystems of the city system [3, 5]. If earlier cities were quite often formed at the intersections of transportation routes, then with their development, the transportation system of the city, which must meet the needs of the economy and the population, becomes extremely important [2]. The larger the city, the more complex its transport system. Therefore, transport systems of large cities and agglomerations are interesting and important objects of scientific research due to their practical direction [6].

In the conditions of active social, political and economic integration of Poland and Ukraine, the aspiration of Ukraine to join the European Union, it is important to study and implement the positive experience of the development of Polish cities and regions, in particular, transport as an element of territorial connectivity, as well as the presentation of positive practices of the development of the transport system of Ukraine [4]. The issues of transport accessibility and its improvement are relevant for urban agglomerations, which are complex spatial systems, the territorial framework of which is largely shaped by the transport system itself.

**Analysis of recent research and publications.** A wide range of works by domestic and foreign scientists in various fields are devoted to the study of the transport infrastructure of cities and the peculiarities of the organization of logistics activities. These are the works of A. De Palma [2], A. Raza [13], H. Behbahani [1], L. Niemets [5], N. Malys [4], O. Nosovska [6], O. Shiba [14], R. Stachyra [16], T.H. Wu [18], W. Fan [3] and others. In particular, a significant number of works are devoted to the study of transport infrastructure and logistics at the level of regions or cities as poles of growth.

In modern scientific literature, transport is considered as a specific communication infrastructural branch of material production and the sphere of service, which provides the needs of the population and the economy from all types of transportation. The components of transport infrastructure, the principles and systems of transport infrastructure management, and the necessary conditions for its effective functioning are important issues that require disclosure. Transport infrastructure is mostly considered as a set of interacting types of transport, state, sectoral, local management bodies, transport enterprises and personnel, communication routes and means of transport, regardless of the forms of ownership and departmental affiliation, which ensure satisfaction of the needs of the population and subjects of economic activity in the transportation of passengers and cargo.

**Identification of previously unsolved parts of the general problem and the purpose of the study.** Taking into account the existing discussions about the features of the transformation of the transport system of Ukrainian cities as a result of military actions, the importance of restoring and optimizing their functioning, an extremely important task is to identify the features of transport accessibility of social institutions and public

institutions of large cities of Ukraine. The purpose of the work is to study the transport accessibility and infrastructural support of the agglomeration cities, the millionaires of Warsaw (Poland) and Kharkiv (Ukraine) in the aspect of applying European experience in Ukraine.

**Research methodology.** The research was conducted within the subject-object field of social geography using its theoretical and methodological apparatus. Systemic, synergistic, socio-geographic and informational approaches were used in the study of transport accessibility. The methodological basis of the work is social-geographical, functional-target, systemic, synergistic, logistic approaches and conceptual positions used in social geography in the study of transport systems. The work used general scientific methods: dialectics and historicism, comparison, analysis and synthesis, classification and typology, generalization, modeling, formalization; interdisciplinary methods (mathematical statistics, pragmatic) and special (cartographic, ranking, graphoanalytical method of multidimensional classification, grouping, cluster analysis, factor analysis, modeling of geographic systems. Computer methods of processing and visualization of research results using ArcGIS and QGIS software packages are also used [10, 11].

A cartographic research method was chosen to assess the transport accessibility to educational institutions in Kharkiv and Warsaw by different modes of transport in Kharkiv. In particular, ArcGis 10.7 and QGIS 3.16 software were used. The database for the study was an interactive OpenStreetMap map. Layers were loaded from the OpenStreetMap with the help of the OverpassTurbo service, and shape files of bus, tram, trolleybus, subway, and SKM routes, stops (stations) on them and administrative districts of Kharkiv and Warsaw were created. Shapefile is a simple, non-topological format for storing geometric location and attributive information of geographical objects [11]. Geographical objects in a shapefile can be represented by points, lines, or polygons (areas). The next step was to build buffer zones in the ArcGis 10.7 software. The buffer zone is an area that is located within the specified distance from the selected real-world object and is designed to separate some real-world objects from others. The buffer distance may vary depending on the numerical value provided in the attribute table of the vector layer for each object. Numerical values should be indicated in the values of the map in accordance with the map projection in which the data is stored. A common example of buffer zones would be green spaces between residential commercial zones, border zones between states, noise protection zones around airports, or pollution protection zones along rivers [15]. In our study, we consider buffer zones as urban transport service areas (real-world objects are urban transport routes) and chose a distance of 500 m from urban transport routes. They correspond to approximately 5-minute accessibility to public transport routes. Based on the results of using the "Buffer Zones" tool, appropriate new shape files are created and transport accessibility maps are built by modes of public transport in the studied cities. These maps display the

boundaries of city districts, routes by types of public transport and stops (stations) on them and directly buffer zones.

Transport accessibility to preschool educational institutions in Kharkiv and Warsaw was also evaluated using ArcGis 10.7 program. To do this, using the OverPassTurbo service, the shapefiles of preschool educational institutions were downloaded from the interactive OpenStreetMap map. After that, maps of transport accessibility by types of public transport in the studied cities were built. They demonstrate the boundaries of city districts, routes by modes of public transport, stops (stations) on them, buffer zones for each mode of transport, for all of them and a network of preschool educational institutions.

The next step was to establish the number of preschools which are within the buffer zones of public transport routes. To do this, the “Selection by Location” tool and the “Select features from target layers” (selection method) and “Intersect the source layer feature (spatial selection method for target layer (s))” options were used in the ArcGis 10.7 software package. The target layer is a layer (shape file) of preschool educational institutions, and the source layer is a layer (shape file) of buffer zones. This tool and options allow sampling from preschools which are within the buffer zones of public transport routes. Then, using the attributive table (shape file) of preschool educational institutions, the difference between them and the total number of preschool educational institutions is calculated better transport accessibility is to preschool educational institutions.

**Presenting main material.** There is quite close cooperation between the cities of Kharkiv and Warsaw, twinning ties between the cities at all levels of administration, as well as local communities, scientists, etc., are intensively developing. The agreement was signed on February 2, 2011 in on friendship and cooperation between the cities of Kharkiv and Warsaw. From the standpoint of this comprehensive study, we note that Kharkiv and Warsaw have not only many common features of development, but also certain differences [7, 8]. Both cities have a rich history, are cities of millionaires, powerful industrial, service, educational, cultural and innovation centers. Warsaw is the capital of Poland, for a certain time the city of Kharkiv also performed the function of the capital. It was at that time that many socio-economic, cultural, industrial and innovative functions were established, which continue to develop in our time and play an important role in the functioning and development of the city. Both cities have a historical center, buildings of different historical stages of development. Also, both Kharkiv and Warsaw are centers of powerful agglomerations. Also, Warsaw is already an officially recognized world alpha city, a smart city, therefore its experience of development and, especially, post-war recovery is extremely relevant and useful in the modern realities of Ukraine, because during the Second World War the Polish capital suffered the greatest destruction among European cities — 84 % of buildings were destroyed [7].

The quality of transport infrastructure and the

provision of logistics services primarily contribute to the accessibility or ease with which people can reach their main destinations, such as work, health care and education, using a particular mode of transport, or a combination of these. Transport accessibility of social institutions is an important factor in the efficiency of the functioning of the city transport system [13]. Every transport system strives for multimodal development – high-level integration for all types of urban transport. Transportation accessibility of educational institutions in the city is extremely important, because it is an opportunity for parents to optimize their time and quickly get to kindergarten or school before and after work, for children of middle and high school age and students - to increase the safety of the road to the educational institution. For the city of Kharkiv, the predominant mode of transport for passenger transportation is the metro. The metro connects all areas of the city (although the city center undoubtedly has a higher concentration of metro stations than the peripheral parts), radial trolleybus routes (in the most densely populated, sleeping areas) and bus routes operate from the metro stations. Thus, any location in the city can be reached by using one or two types of public transport. However, during the planning of the development of the city infrastructure, the rejection of new, including private educational institutions.

According to OpenStreetMap, there are 170 preschool educational institutions in Kharkiv [10]. Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 10 preschool educational institutions (6%) are not within the buffer zones of bus routes, which indicates that these institutions are not located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 1). Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 42 preschool educational institutions (25%) are within the buffer zones of bus routes, which indicates that these institutions are located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 2).

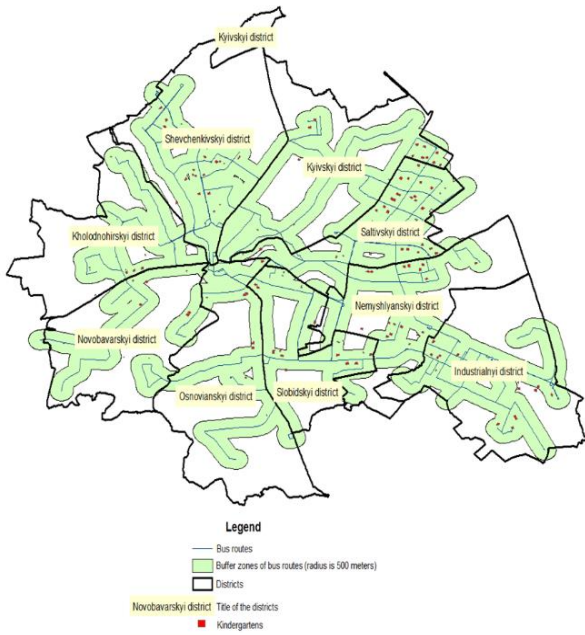
So, as we can see, the majority of preschool education institutions have a sufficiently high level of transport accessibility of the metro, and combining it with bus transport, it is possible to ensure the transport accessibility of more than 90% of preschool education institutions in the city of Kharkiv.

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 78 preschool educational institutions (46%) are within the buffer zones of tram routes, which indicates that these institutions are located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 3). Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 131 preschool educational institutions (77%) are within the buffer zones of bus routes, which indicates that these institutions are located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 4) [9].

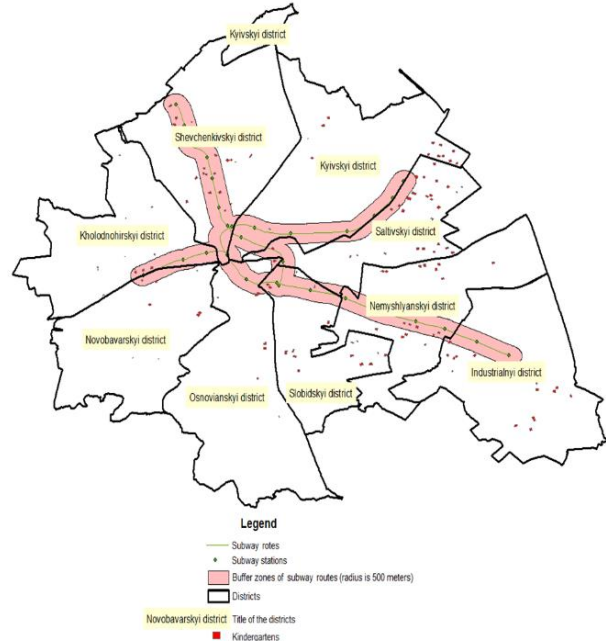
The use of urban ground electric transport provides a lower level of transport accessibility for preschool education institutions. For the most part, these types of transport are aimed at connecting sleeping areas of the city and places of employment. We will analyze the transport accessibility of preschool educational

institutions by all types of transport (Fig. 5).

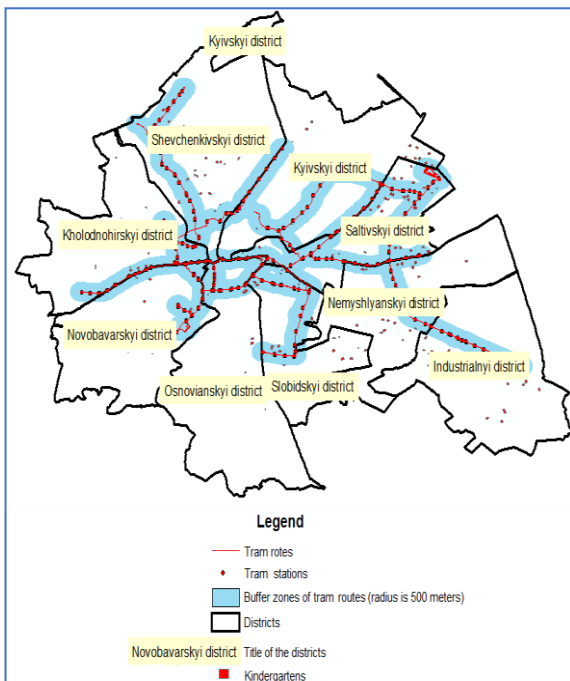
Transport analysis of the accessibility of preschool education institutions by all types of transport found that 4 institutions of this type (2%) are outside a 5-minute accessibility.



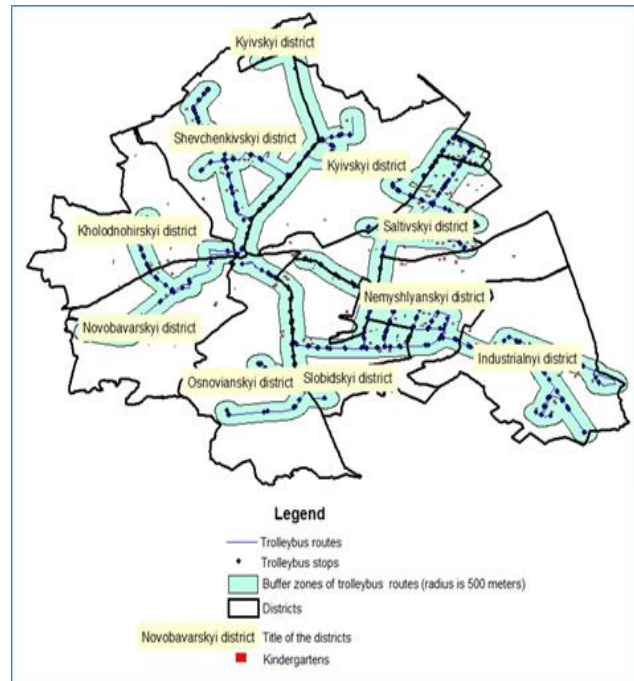
**Fig. 1. Transport accessibility to preschool educational institutions (kindergartens) by bus transport in Kharkiv (compiled by the author according to [10])**



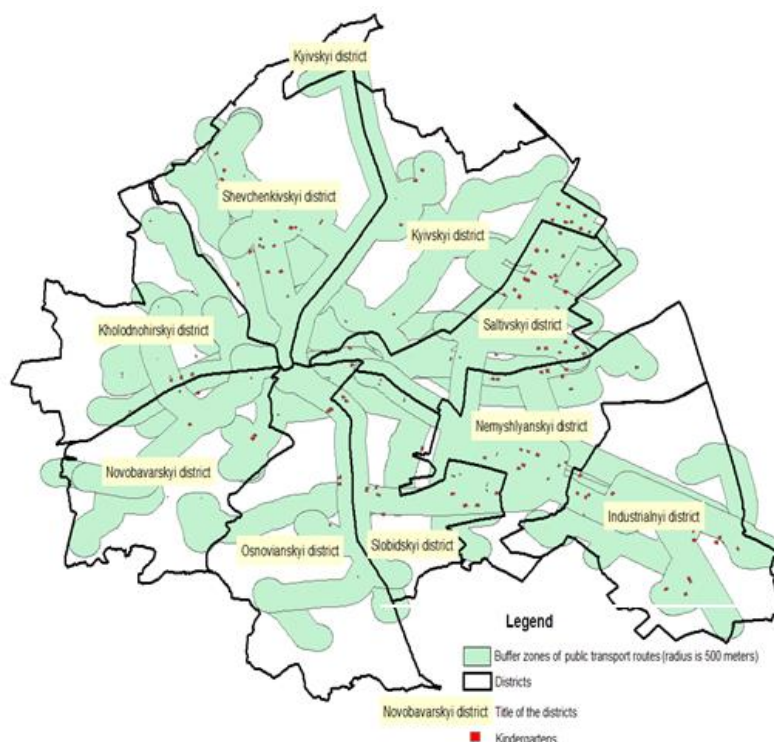
**Fig. 2. Transport accessibility to preschool educational institutions (kindergartens) by subway in Kharkiv (compiled by the author according to [10])**



**Fig. 3. Transport accessibility to preschool educational institutions (kindergartens) by tram transport in Kharkiv (compiled by the author according to [10])**



**Fig. 4. Transport accessibility to preschool educational institutions (kindergartens) by trolleybus transport in Kharkiv (compiled by the author according to [10])**



**Fig. 5. Transport accessibility to preschool educational institutions by all types of public transport in the city of Kharkiv (compiled by the author according to [10])**

According to OpenStreetMap data, there are 215 secondary educational institutions in Kharkiv [10]. Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 8 secondary educational institutions (4%) are not within the buffer zones of bus routes, which indicates that these institutions are not located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 6). Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 55 secondary educational institutions (26%) are within the buffer zones of bus routes, which indicates that these institutions are located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 7). Transportation accessibility of secondary education facilities by subway is insufficient and usually involves the use of several types of transportation, or the availability of other timings on foot. However, in 2023-2024 in the city of Kharkiv, the “Metroshkola” project was launched, which ensures almost 100% transport accessibility of schools, because they are actually located in metro stations, which at the same time act as a safe space and a shelter.

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 94 secondary educational institutions (44%) are within the buffer zones of tram routes, which indicates that these institutions are located in the zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig 8).

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 154 secondary educational institutions (72%) are within the buffer zones of trolleybus routes, which indicates that these institutions are located in the

zone of 500 meters (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 9). As we can see, trams are mostly designed to connect sleeping areas and workplaces of the population. However, trolleybus routes partially provide connections between sleeping areas and secondary education institutions of the city.

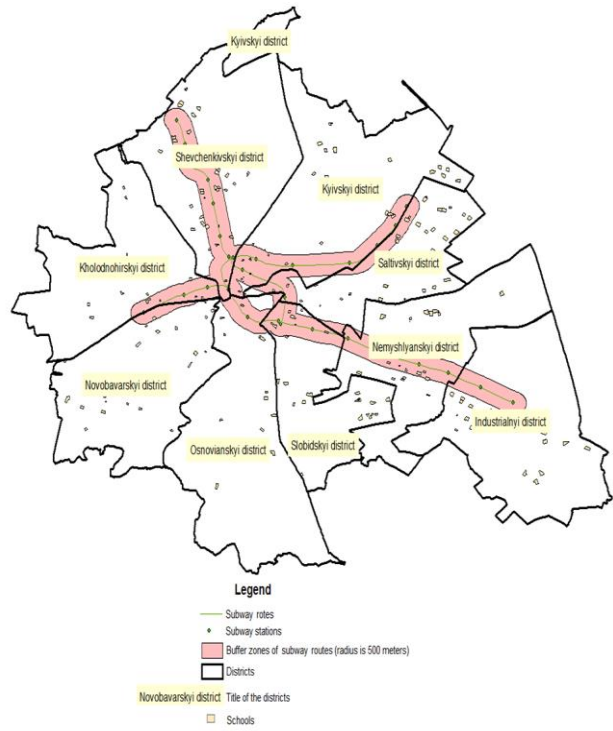
We will analyze the transport accessibility of preschool educational institutions by all types of transport (Fig. 10). And it was found that 2 secondary educational institutions (1%) are not within the buffer zones of all modes of public transport routes, which indicates that these institutions are not located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of all modes of public transport (Fig. 10).

The analysis of transportation accessibility of preschool and general education institutions in the city of Kharkiv proved that most of them are located in the zone of sufficient transportation accessibility, however, such accessibility is mostly provided by a combination of several types of public transportation, mostly - metro and one of the three types of ground public transport in the city.

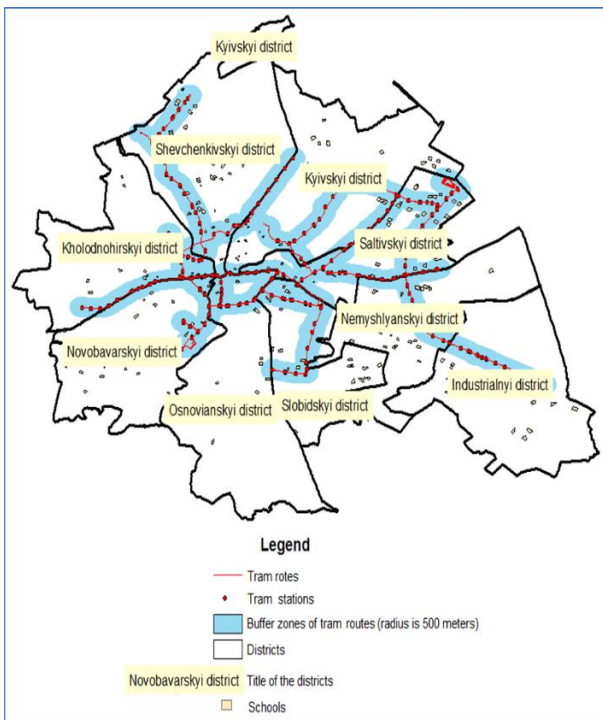
We will analyze the availability of pre-school and secondary education institutions in the city of Warsaw. According to OpenStreetMap, there are 610 preschool educational institutions in Warsaw (OpenStreetMap). Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 10 preschool educational institutions (2%) are not within the buffer zones of bus routes, which indicates that these institutions are not located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 11).



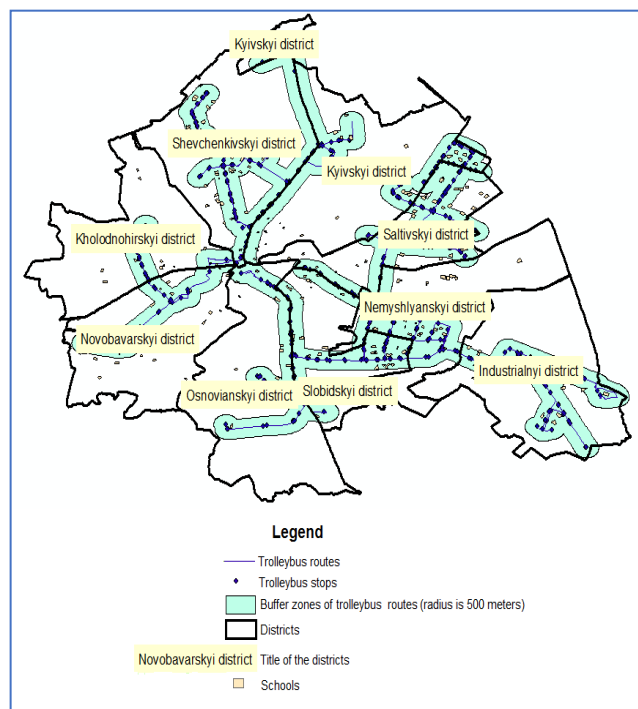
**Fig. 6. Transport accessibility to secondary educational institutions (schools) by bus transport in Kharkiv (compiled by the author according to [10])**



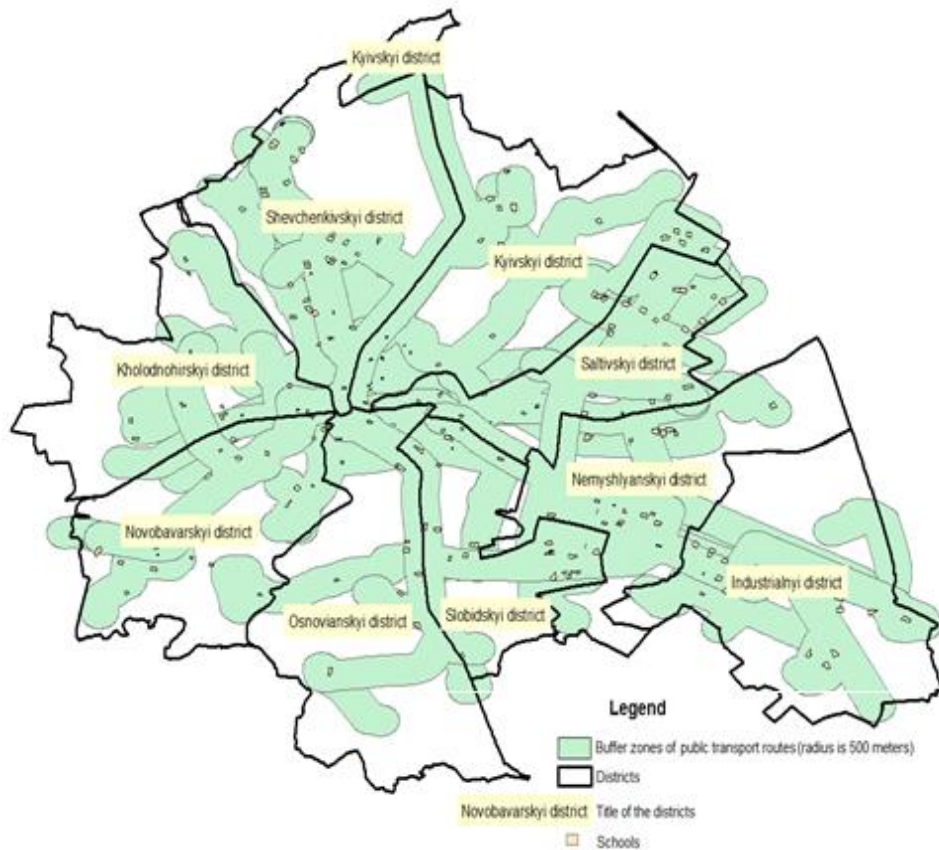
**Fig. 7. Transport accessibility to the secondary educational institutions (schools) by subway in Kharkiv (compiled by the author according to [10])**



**Fig. 8. Transport accessibility to the secondary educational institutions (schools) by tram transport in Kharkiv (compiled by the author according to [10])**



**Fig. 9. Transport accessibility to the secondary educational institutions (schools) by trolleybus transport in Kharkiv (compiled by the author according to [10])**



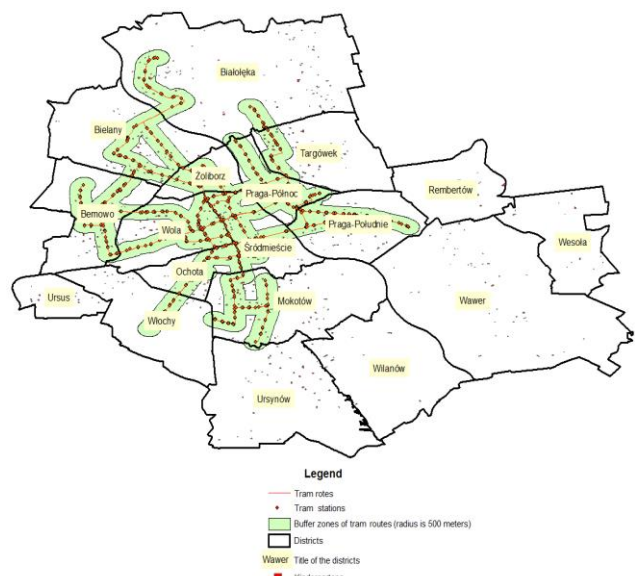
**Fig. 10. Transport accessibility to the secondary educational institutions by all modes of public transport in Kharkiv (compiled by the author according to [10])**

Analyzing the peculiarities of the transport system of the city of Warsaw, it is worth noting that the largest volume of passenger transportation is concentrated on buses. Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, As you can see, the bus network covers the city of Warsaw almost comprehensively, providing transport accessibility to preschool education institutions. It was

found that 234 preschool educational institutions (38%) are within the buffer zones of tram routes, which indicates that these institutions are located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 12 ). Accessibility by tram is much lower, with tram lines operating in the central and north-western parts of the city.



**Fig. 11. Transport accessibility to preschool educational institutions (kindergartens) by bus transport in Warsaw (compiled by the author according to [10])**



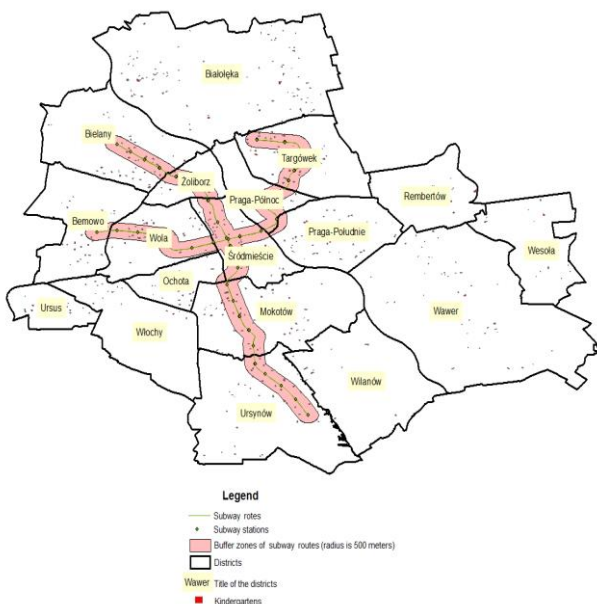
**Fig. 12. Transport accessibility to preschool educational institutions (kindergartens) by trams in Warsaw (compiled by the author according to [10])**

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 153 preschool educational institutions (25%) are within the buffer zones of subway routes, which indicates that these institutions are located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 13). In Warsaw, the subway does not play such a dominant role in ensuring transport accessibility, as in Kharkiv, there are areas where there is no subway.

The city high-speed train is quite an effective solution for such a big city as Warsaw. It provides high-speed connections in the city from north to south and from west to east. Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software

package, it was found that 83 preschool educational institutions (14%) are within the buffer zones of routes of fast urban railway (SKM), which indicates that these institutions are located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 14).

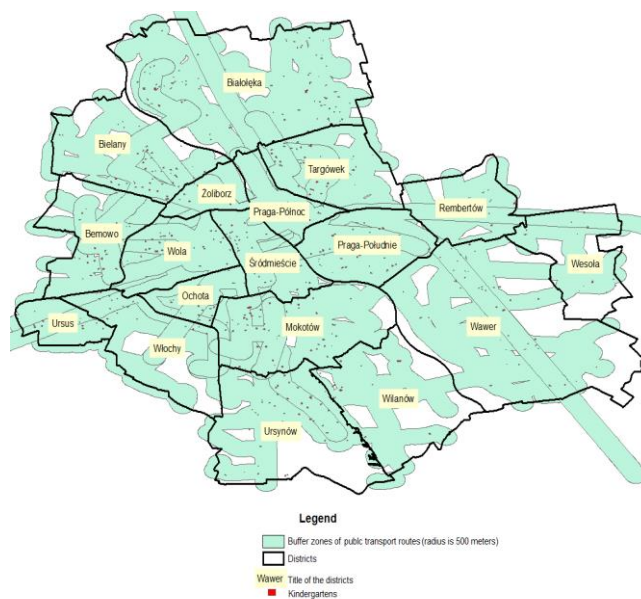
Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 10 preschool educational institutions (2%) are not within the buffer zones of routes of all public transport, which indicates that these institutions are not located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of public transport (Fig. 15).



**Fig. 13. Transport accessibility to preschool educational institutions by subway in Warsaw (compiled by the author according to [10])**



**Fig. 14. Transport accessibility to preschool educational institutions (kindergartens) by fast urban railway (SKM) in Warsaw (compiled by the author according to [10])**



**Fig. 15. Transport accessibility to preschool educational institutions (kindergartens) by all types of public transport in Warsaw (compiled by the author according to [10])**



Analyzing the comprehensive model of transportation accessibility of preschool educational institutions, it is worth noting that it is almost 100%. The presence of an extensive, intermodal network allows you to get to the required location quite quickly, using mainly 1, and less often - several types of public transport [17].

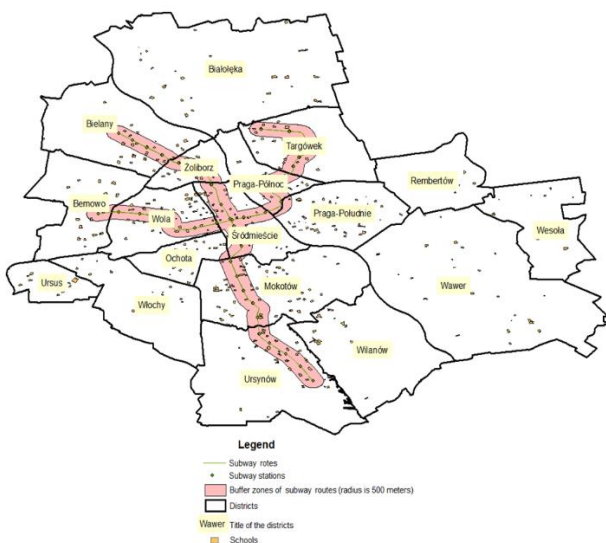
According to OpenStreetMap, there are 471 preschool educational institutions in Warsaw [10]. Based on the results of using the “Selection by Location” tool in the ArcGIS 10.7 software package, it was found that 3 preschool educational institutions (1%) are not within the buffer zones of bus routes, which indicates that these institutions are not located in the zone of 500 meters (approximately 5-minute) accessibility to these routes



**Fig. 16. Transport accessibility to the secondary educational institutions (schools) by buses in Warsaw (compiled by the author according to [10])**



**Fig. 17. Transport accessibility to the secondary educational institutions (schools) by trams in Warsaw (compiled by the author according to [10])**



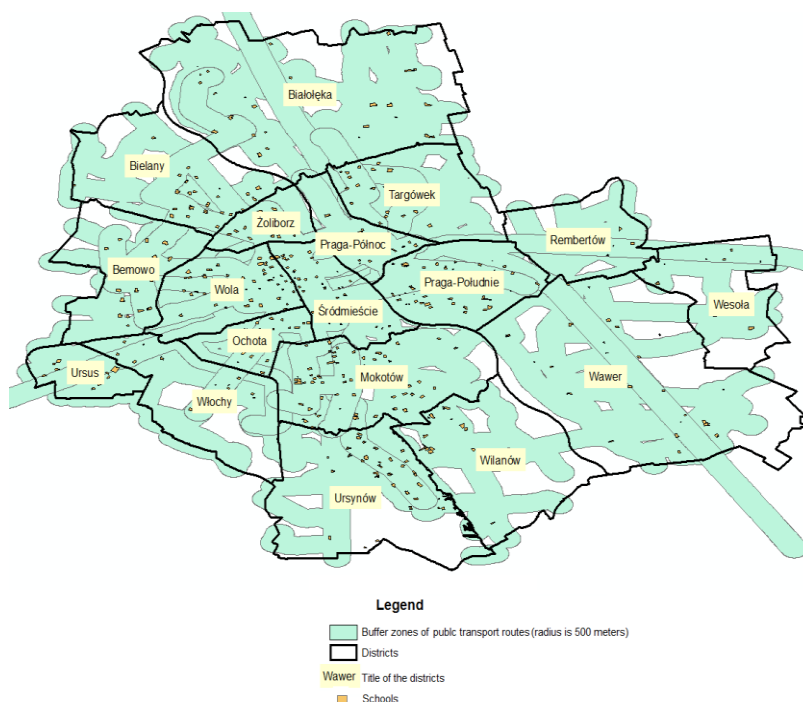
**Fig. 18. Transport accessibility to the secondary educational institutions by subway in Warsaw (compiled by the author according to [10])**



**Fig. 19. Transport accessibility to the secondary educational institutions (schools) by fast urban railway (SKM) in Warsaw (compiled by the author according to [10])**

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 77 preschool educational institutions (16%) are within the buffer zones of the routes of fast urban railway (SKM), which indicates that these institutions are located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 19).

Based on the results of using the “Selection by Location” tool in the ArcGis 10.7 software package, it was found that 3 secondary educational institutions (1%) are within the buffer zones of routes of all modes of public transport, which indicates that these institutions are located in the zone of 500 meter (approximately 5-minute) accessibility to the routes of this mode of transport (Fig. 20).



**Fig. 20. Transport accessibility to the secondary educational institutions (schools) by all modes of public transport in Warsaw (compiled by the author according to [10])**

Comparing transport accessibility to preschool educational institutions by all modes of public transport in Kharkiv and Warsaw (Table 1), it should be said that in general, by mode of transport, the share of the number of institutions located within the buffer zones is approximately the same. The differences are the

following: the share of preschool educational institutions for trams in Kharkiv is 46%, in Warsaw – 38%, there is not the fast urban railway in Kharkiv, and trolleybuses in Warsaw. A number of preschool educational institutions in Warsaw is 3.5 times more than in Kharkiv.

*Table 1*

**Transport accessibility to preschool educational institutions by all modes of public transport in Kharkiv and Warsaw (compiled by the author according to [10])**

Category	Kharkiv		Warsaw	
	Number of preschool educational institutions located within the buffer zones	Share of preschool educational institutions located within the buffer zones (%)	Number of preschool educational institutions located within the buffer zones	Share of preschool educational institutions located within the buffer zones (%)
Number of preschool educational institutions	170		610	
Bus transport	160	94	600	98
Subway	42	25	153	25
Tram transport	78	46	234	38
Trolleybus transport	131	77		
Fast Urban Railway (SKM)			83	14
All modes of public transport	166	98	600	98

Comparing transport accessibility to the secondary educational institutions by all modes of public transport in Kharkiv and Warsaw (Table 2), it should be said that in general, by mode of transport, the share of the number of institutions located within the buffer zones is

approximately the same. The differences are as follows. There is no fast urban railway in Kharkiv, and trolleybuses in Warsaw. A number of secondary educational institutions in Warsaw is almost twice more in Kharkiv.

Table 2

*Transport accessibility to the secondary educational institutions by all modes of public transport in Kharkiv and Warsaw (compiled by the author according to [10])*

Category	Kharkiv		Warsaw	
	Number of secondary educational institutions located within the buffer zones	Share of secondary educational institutions located within the buffer zones (%)	Number of secondary educational institutions located within the buffer zones	Share of secondary educational institutions located within the buffer zones (%)
Number of secondary educational institutions	215		471	
Bus transport	207	96	468	99
Subway	55	26	127	27
Tram transport	94	44	242	51
Trolleybus transport	154	72		
Fast Urban Railway (SKM)			77	16
All modes of public transport	213	99	607	99

The number of educational institutions located within the buffer zones is almost 90%: out of 215 schools, 213 are located within the buffer zones of public transport, which indicates the high accessibility of schools with the help of transport infrastructure.

The majority of educational institutions (96%) in Kharkiv are located within the buffer zones of bus routes, which indicates a wide coverage of this type of transport. Kharkiv metro provides access to 26% of schools in the city. Also, a significant part of educational institutions (44%) in Kharkiv is located within the buffer zones of tram routes, which increases the accessibility of educational institutions. Trolleybuses provide access to 72% of schools in the city, which highlights their important role in the transport infrastructure.

Transportation accessibility of educational institutions in Kharkiv is high thanks to a large network of public transport. Buses, trolleybuses and trams play a key role in making schools accessible, covering most of the city. The presence of the metro expands the possibilities of fast and efficient transport connections with educational institutions. The total percentage of schools located within public transport buffer zones confirms the effectiveness of the city's transport infrastructure in providing access to education.

The majority of educational institutions (99%) in Warsaw are located within the buffer zones of bus routes, which indicates a wide coverage of this mode of transport. The metro provides access to 27% of schools in the city. A significant part of schools (51%) in Warsaw is located within the buffer zones of tram routes, which increases the accessibility of educational institutions.

Rapid City Rail (SKM): SKM provides accessibility to 16% of schools in the city, which can be an important

means of rapid transportation to educational institutions. Transportation accessibility of educational institutions in Warsaw is also high thanks to a diverse network of public transport.

Buses, trams, metro and SKM play a key role in making schools accessible, covering most of the city. The presence of the metro and SKM expands the possibilities of fast and efficient transportation to educational institutions, especially for residents of remote areas. The total percentage of schools located within public transport buffer zones confirms the effectiveness of the city's transport infrastructure in providing access to education.

**Conclusions.** The research topic of the transport systems of the cities of Warsaw and Kharkiv turned out to be surprisingly interesting and important from the point of view of the socio-geographical approach. The peculiarities of the place of transport in the general social infrastructure, as well as its influence on the functioning of institutions of the social sphere, especially educational at the level of its middle link, were studied. It is noted in particular that the cities of Kharkiv and Warsaw have a high level of transport accessibility to educational institutions, as more than 99% of schools are located within the buffer zones of public transport.

Warsaw has a wider choice of means of transport, which provides higher accessibility to educational institutions, especially in the categories of buses, trams and metro, than in Kharkiv. Warsaw also has a high-speed urban railway (SKM), which can provide fast and convenient transport links to educational institutions.

In Kharkiv, transport accessibility to educational institutions is based mainly on the metro, bus and trolleybus connections. This study is important for the post-war reconstruction of the city of Kharkiv. Issues

related to the restoration of the infrastructure of educational institutions destroyed by the war, as well as experience in ensuring the safety of their functioning, require further research in the aspect of the subject-object field of social geography. We are talking about the unique experience of Kharkiv, in particular the metro school, underground schools, etc. The analysis of the

functioning of Warsaw's transport infrastructure allows further research to take into account elements of the development of the European transport system. The issue of the demographic situation, on the basis of which a more optimal reform of the entire social infrastructure, including the transport one, is possible requires further research.

#### References:

- Behbahani, H., Nazari, S., Jafari K., M., & Litman, T. (2019). A conceptual framework to formulate transportation network design problem considering social equity criteria. *Transp. Res. Part A: Policy Pract.* 125(C), 171-183.
- De Palma, A., Lindsey, R., Quinet, E., & Vickerman, R. (2017). *The Routledge Handbook of Transport Economics* (Edited By Jonathan Cowie, Stephen Ison). – 1st Edition, 2017, 460.
- Fan, W., & Machemehl, R.B. (2011). Bi-level optimization model for public transportation network redesign problem: Accounting for equity issues. *Transp. Res. Rec.* 2263 (1), 151-162. <https://doi.org/10.3141/2263-17>.
- Malysh, N. (2016). Transport infrastructure of Ukraine under the conditions of implementation of the Association Agreement with the EU. *Development of the accounting, analysis and audit system in Ukraine: theory, methodology, organization: materials Vseukr. of science conf.*, Kyiv: NASOA, 146-149 [in Ukrainian].
- Niemets, L., Sehida, K. et.al. (2017). Innovatsiyno-investytsiynyy potentsial yak osnova konkurentospromozhnosti (na prykladi Kharkivs'koyi oblasti): kolektyvna monohrafiya [Innovation and investment potential as the basis of competitiveness (case study of Kharkiv region, coll. monograph. Kharkiv), V.N. Karazin Kharkiv National University, 2017, 520 p. [in Ukrainian].
- Nosovska, O. (2014). Problems and prospects for the development of transport infrastructure of Ukraine. *Bulletin of the Pryazovsky State Technical University*, 27, 5-14 [in Ukrainian].
- Official website of Warsaw City. Retrieved from <https://ua.um.warszawa.pl/> [in Ukrainian].
- Official website of Kharkiv City Council, Mayor. Retrieved from <https://www.city.kharkov.ua/> [in Ukrainian].
- Official website of the Main Department of Statistics in the Kharkiv region. Retrieved from <http://kh.ukrstat.gov.ua/>
- OpenStreetMap. Retrieved from <https://www.openstreetmap.org/>
- OverpassTurbo. Retrieved from <https://overpass-turbo.eu/>
- Public transport step by step. Warsaw Public Transport. Retrieved from <https://www.wtp.waw.pl/en/public-transport-step-by-step/> [in Ukrainian].
- Raza, A., Zhong, M., Akuh, R., & Safdar, M. (2023). Public transport equity with the concept of time-dependent accessibility using Geostatistics methods, Lorenz curves, and Gini coefficients. *Case Studies on Transport Policy*, 11, <https://doi.org/10.1016/j.cstp.2023.100956>
- Shiba, O. (2016). Strategy for the development of transport infrastructure of Ukraine in the conditions of European integration. *Black Sea Economic Studies*, Part 8, 35-40 [in Ukrainian].
- Spatial analysis of vector data (Buffer). QGis documentation. Retrieved from [https://docs.qgis.org/3.4/ru/docs/gentle\\_gis\\_introduction/vector\\_spatial\\_analysis\\_buffers.html](https://docs.qgis.org/3.4/ru/docs/gentle_gis_introduction/vector_spatial_analysis_buffers.html)
- Stachyra, R., & Roman, K. (2021). Analysis of Accessibility of Public Transport in Warsaw in the Opinion of Users. *Postmodern Openings, Editura Lumen, Department of Economics*, 12(3), 384-403.
- Warsaw's transport. Retrieved from <https://yavpohode.net/files/warsaw-strefa> [in Ukrainian].
- Wu, T.H. (2014). Research on layout planning of town center for public service facilities configuration. *Dev. Small Cities Towns*, 11 (2014), pp. 39-47.
- ZTM annual reports. Public Transport Authority in Warsaw. Retrieved from <https://www.ztm.waw.pl/raporty-roczne-ztm/> [in Ukrainian].

#### Катерина Кравченко

к. геогр. н., доцент кафедри соціально-економічної географії і регіоназнавства імені Костянтина Немця, Харківський національний університет імені В.Н. Каразіна, майдан Свободи, 4, м. Харків, 61022, Україна  
e-mail: [kateryna.kravchenko@karazin.ua](mailto:kateryna.kravchenko@karazin.ua), <https://orcid.org/0000-0003-4654-3185>

#### Євген Шнак

аспірант кафедри соціально-економічної географії і регіоназнавства імені Костянтина Немця, Харківський національний університет імені В.Н. Каразіна, майдан Свободи, 4, м. Харків, 61022, Україна  
e-mail: [yevhenstarling@gmail.com](mailto:yevhenstarling@gmail.com), <https://orcid.org/0009-0000-7035-0389>

#### Євген Хабусев

аспірант кафедри соціально-економічної географії і регіоназнавства імені Костянтина Немця, Харківський національний університет імені В.Н. Каразіна, майдан Свободи, 4, м. Харків, 61022, Україна  
e-mail: [evgenijh7@gmail.com](mailto:evgenijh7@gmail.com), <https://orcid.org/0009-0005-7407-0364>

## СУСПІЛЬНО-ГЕОГРАФІЧНІ ОСОБЛИВОСТІ ДОСЛІДЖЕННЯ ТРАНСПОРТНОЇ ДОСТУПНОСТІ ЗАКЛАДІВ ДОШКІЛЬНОЇ ТА СЕРЕДНЬОЇ ОСВИТИ МІСТ ХАРКІВ ТА ВАРШАВА

Ефективна транспортна система є однією з важливих елементів економічно розвинутого міста. Якість транспортної інфраструктури та забезпечення логістичних послуг насамперед сприяють доступності або легкості, з якою люди можуть дістатися до основних місць призначення, таких як робота, заклади охорона здоров'я та освітні заклади, використовуючи певний вид транспорту, або їх комбінацію. В роботі проведено суспільно-географічний аналіз транспортної доступності дошкільних та загальноосвітніх навчальних закладів у Харкові та Варшаві. Наведено особливості методики дослідження транспортної доступності за допомогою геоінформаційних систем QGIS 3.16 та ArcGis 10.7. на основі даних відкритого ресурсу OpenStreetMap. На основі просторового ГІС-аналізу розміщення закладів дошкільної та середньої освіти було побудовано буферні зони, які покривають територію в зоні 500-метрової (орієнтовно 5-хвилинної) доступності.

Встановлено, що міста Харків та Варшава мають добре розвинену транспортну інфраструктуру, у місті Харків у структурі пасажиробігу за видами транспорту превалює метрополітен, у місті Варшава – автобусний транспорт. Порівняльний аналіз доступності дошкільних навчальних закладів за усіма видами громадського транспорту в Харкові та Варшаві засвідчив, що в цілому за видами транспорту частка кількості закладів, розташованих у буферних зонах є фактично однаковою. Кількість дошкільних навчальних закладів у Варшаві в 3,5 рази більше, ніж у Харкові. В ході дослідження транспортної доступності загальноосвітніх навчальних закладів усіма видами громадського транспорту в Харкові та Варшаві встановлено, що в цілому за видами транспорту частка закладів, розташованих у буферних зонах, є майже рівною, кількість середніх навчальних закладів у Варшаві майже вдвічі більша у Харкові. Кількість навчальних закладів, розташованих у буферних зонах, становить майже 90%: із 215 шкіл 213 розташовані у буферних зонах громадського транспорту. Більшість навчальних закладів (99%) Варшави розташовані в буферних зонах автобусних маршрутів, що свідчить про широке охоплення цього виду транспорту. Метро забезпечує доступ до 27% шкіл міста. Значна частина шкіл (51%) у Варшаві знаходиться в буферних зонах трамвайних маршрутів, що підвищує доступність навчальних закладів.

Загалом міста Харків і Варшава характеризуються доволі високим рівнем транспортної доступності до освітньої інфраструктури, оскільки понад 99% навчальних закладів розташовані в межах буферних зон громадського транспорту, що підтверджує ефективність транспортної інфраструктури міст щодо забезпечення доступу до закладів дошкільної та середньої освіти.

**Ключові слова:** транспортна інфраструктура, транспортна доступність, заклади освіти, буферні зони, громадський транспорт.

### Список використаної літератури:

- Behbahani H.A. conceptual framework to formulate transportation network design problem considering social equity criteria / H. Behbahani, S. Nazari, K. Jafari, T. Litman. *Transp. Res. Part A: Policy Pract.* № 125, 171-183.
- De Palma. *The Routledge Handbook of Transport Economics* / A. De Palma, R. Lindsey, E. Quinet, R. Vickerman - 1st Edition, 2017, 460 p.
- Fan W. Bi-level optimization model for public transportation network redesign problem: Accounting for equity issues / W. Fan, R.B. Machemehl. - *Transp. Res. Rec.* 2263 (1), 2011, 151–162. <https://doi.org/10.3141/2263-17>.
- Малиш Н.А. Транспортна інфраструктура України в умовах імплементації Угоди про асоціацію з ЄС / Н.А. Малиш // Розвиток системи обліку, аналізу та аудиту в Україні: теорія, методологія, організація: матеріали Всеукр. наук. конф. – Київ: НАСОА, 2016. – С. 146-149.
- Інноваційно-інвестиційний потенціал як основа конкурентоспроможності регіону (на прикладі Харківської області): колективна монографія / за заг. ред. Л. Немець, К. Сегіди. – Харків: ХНУ імені В.Н. Каразіна, 2017. – 520 с.
- Носовська О.Б. Проблеми та перспективи розвитку транспортної інфраструктури України / О.Б. Носовська, М.В. Макаренко // Вісник Приазовського державного технічного університету. – 2014. – Вип. 27. – С. 5-14.
- Офіційний сайт міста Варшава. [Електронний ресурс]. – Режим доступу: <https://ua.um.warszawa.pl/>
- Офіційний сайт Харківської міської ради, міського голови, виконавчого комітету [Електронний ресурс]. – Режим доступу: <https://www.city.kharkov.ua/>
- Official website of the Main Department of Statistics in the Kharkiv region [Електронний ресурс]. – Режим доступу: <http://kh.ukrstat.gov.ua/>
- OpenStreetMap [Електронний ресурс]. – Режим доступу: <https://www.openstreetmap.org/>
- OverpassTurbo. [Електронний ресурс]. – Режим доступу: <https://overpass-turbo.eu/>
- Громадський транспорт крок за кроком. Громадський транспорт Варшави [Електронний ресурс]. – Режим доступу: [www.wtp.waw.pl/en/public-transport-step-by-step](http://www.wtp.waw.pl/en/public-transport-step-by-step)
- Raza A. Public transport equity with the concept of time-dependent accessibility using Geostatistics methods, Lorenz curves, and Gini coefficients / A. Raza, M. Zhong, R. Akuh, M. Safdar // *Case Studies on Transport Policy*. Vol. 11, 2023. <https://doi.org/10.1016/j.cstp.2023.100956>.
- Шибя О. А. Стратегія розвитку транспортної інфраструктури України в умовах євроінтеграції / О.А. Шибя // Причорноморські економічні студії. – 2016. – Ч. 8. – С. 35-40.
- Spatial analysis of vector data (Buffer). QGis documentation [Електронний ресурс]. – Режим доступу: [https://docs.qgis.org/3.4/ru/docs/gentle\\_gis\\_introduction/vector\\_spatial\\_analysis\\_buffers.html](https://docs.qgis.org/3.4/ru/docs/gentle_gis_introduction/vector_spatial_analysis_buffers.html)
- Stachyra R. Analysis of Accessibility of Public Transport in Warsaw in the Opinion of Users / R. Stachyra, K. Roman / *Postmodern Openings*, Editura Lumen, Department of Economics, vol. 12(3), 2021, p. 384-403.
- Транспорт міста Варшава [Електронний ресурс]. – Режим доступу: <https://yavpohode.net/files/warsaw-strefa>
- Wu T.H. Research on layout planning of town center for public service facilities configuration / T.H. Wu. *Dev. Small Cities Towns*, № 11, 2014, p. 39-47.
- Річні звіти ZTM. Управління громадського транспорту у Варшаві. [Електронний ресурс]. – Режим доступу: <https://www.ztm.waw.pl/raporty-roczne-ztm/>

Надійшла 15 березня 2024 р.

Прийнята 28 квітня 2024 р.