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Pandemic resilient cities: Possibilities of repairing Polish towns and cities during COVID-19 pandemic

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A R T I C L E   I N F O

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A B S T R A C T

Cities, due to population density and the complexity of human interactions, experience specific problems arising from their functioning in the era of the Covid-19 pandemic. Many scientists who publish their findings in contemporary literature agree on the need to shape pandemic resilient cities by making changes to the functional-spatial structure and preparing cities for rapid revitalization [regeneration] in the post-pandemic period. The main objective of the research is to identify the most important problems regarding service infrastructure deficiencies in the nine medium-sized Polish cities selected for research located in the Warsaw agglomeration, which are well connected with Warsaw. The research was based on: analysis of selected GIS spatial data, demographic data from the Polish Central Statistical Office, surveys among residents, on their needs during pandemic constraints. The focus was on three important aspects of development in the era of the pandemic: access to first-need services, access to greenery and active recreation areas, accessibility and transport efficiency problems. The research revealed changes in the way people travel and do their essential shopping, inadequate cycling infrastructure and problems with the availability of essential services close to where they live. The research programme varies, although the diagnosis and the possibility of transforming the functional-spatial structure of the cities studied as typical medium-sized cities in the impact zone of a large centre dominate. The conclusions provide examples of proposals for tactical urbanism planning solutions that could rapidly improve the quality of residence in a low-budget way. Finally, the proposals and guidelines for creating sustainable pandemic resilient cities are described. The article investigates the aspect of urban resilience related to transport, services, relaxation, while using the method of tactical urbanism as a remedy for cities’ pandemic problems.

1. Introduction

COVID–19 pandemic outbreak has intensified population migration trends from large cities to suburban areas in search of better living conditions in these unusual times. Indicates an increased interest in areas of small and medium-sized cities and single-family houses with their own gardens as potential places of residence. Charles Montgomery’s statement (2013, pp. 55–62) that there is an increased sense of well-being and satisfaction with the lives of residents of smaller centres is becoming all the more timely. These trends also fit into the growing trend of return to locality (Carmona et al., 2010, p. 38). Unfortunately, smaller cities in Poland do not correspond to the image of cities fitted for people as described in literature (Gehl, 2010; Barton, 2017; Sim, 2019), which should have a compact structure providing distances which can be covered on foot, and in which safe public spaces have been created to allow active city life: shopping, work, entertainment (Carmona et al., 2010, p. 39; Denis et al., 2021, pp. 1–9, Jarecka-Bidzińska, 2020, pp.163–178). The future of contemporary cities also depends on globalization processes which directly influence the rank of particular cities and their role in the settlement network, (Sztompka, 2002) as well as causing metropolisation of space: development of metropolitan cities and stagnation of smaller centres, not equipped with proper functions and quality (Damurski, 2016, p. 49).

In the spatial and social characteristics of Polish cities and towns, one can see the distinctness of their development processes resulting from specific historical conditions. Many negative processes became active after the introduction of systemic changes after 1989, despite many positive aspects such as the introduction of a market economy, the

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restoration of economic value of “land”, the restoration of the “rank” of property rights. Problems have increased especially in smaller towns, located in suburban areas of large centres, which as a result of the influence of stronger units are often marginalized.

Despite the apparent population and surface development, they are evolving towards the dominance of housing or downstream services and become only “dormitory towns” where residents live, but the needs of entertainment, health, higher-order necessities are fulfilled in a larger workplace-related resort.

The spatial structure in cities is becoming increasingly dispersed. Historical centres surround multifunctional development zones (most often in the form of detached single-family houses) without the necessary basic services (Majewska, 2020, pp. 168–172). Extensive, poorly accessible single-family pedestrian areas, although they offer greater contact with the environment, larger gardens and privacy, are consequently dependent on cars and result in harmful social isolation and reduced activity of residents (Barton, 2017, p. 193).

The problem of “dormitory towns” was noticed in Poland as early as the end of the 1960s. At that time a decision was taken (Anon, 1968, “General Plan of the Capital and the Warsaw Urban Complex”) to deglomerate and locate many enterprises in the cities surrounding Warsaw, and an increase in employment and housing in the smaller towns of the suburban zone was assumed. This model functioned until the 1990s, when as a result of the political transformation and progressing globalization, most of these small enterprises ceased to operate, which forced the inhabitants to look for other jobs, often outside their place of residence (in this case, mainly in Warsaw, which offers better financial conditions and a greater variety of employment). This situation results in about 1 million cars entering Warsaw daily (Osowski, 2017), which causes a huge parking problem and affects air quality. Statistically, there are over 800 cars per 1000 inhabitants of Warsaw (the average in Poland is over 600). In comparison, in Berlin there are about 250 registered cars per 1000 inhabitants. The situation of excessive car traffic in Warsaw has changed as a result of the pandemic. In 2020, at all measurement points, the number of passenger cars in relation to 2019, clearly decreased, in some as much as by half (traditionally, most cars enter the centre during the morning rush, in 2020 it was 992 cars, and in 2019 as many as 2047 cars, in the afternoon, in the case of leaving the centre, in 2020 it was 1331 cars, and the year before – 1820 cars). These data confirm the thesis that the problem of the Warsaw suburban zone is the excessive intensity of individual automobile traffic. Unfortunately, in smaller centres there are no traffic surveys showing the increase in its intensity. Therefore, in the analysed cities, the conclusion of increased car traffic was supported by research on the increase in the number of cars per capita and by survey research which indicates that it is dominated by individual car traffic, which is influenced by the considerable functional dispersion and extensive development as well as the lack of sufficient public transport (bus) within the city and municipality. All surveyed cities are connected by rail or bus (Warsaw public transport), but usually these lines are heavily loaded with passengers. It was difficult for them to maintain the necessary distance needed as a result of the pandemic (Szotyrek et al., 2016, p. 42). Therefore, those who commuted to work and shopping were more likely to use their own cars, believing that this offered greater safety and protection from infection. Unfortunately, as research shows, even increased urban density does not always result in a reduction in car use for daily commuting. In post-socialist cities, there is still a tendency to equate car ownership with higher social status, resulting in the use of car as the mode of transport even for short travel distances (Szotyrek et al., 2016, p. 42).

The lack of well-landscaped green areas (squares, outdoor gyms, small parks) near one’s own home, the lack of coherent bike paths, as well as meeting places for residents is becoming a serious problem. In the era of the COVID-19 pandemic, the essence of action should be the correlation between public health and sustainable urban planning and the process of the regeneration of towns (Barbarossa, 2020, pp. 2–3; Elgheznawy and Eltarabily, 2020, pp. 75–84; Lai et al., 2020, pp. 27–31; Urban Heritage Conservation and Sustainable Development Research Team, 2020).

The development structure of Polish cities consists mainly of single-family housing zones, where plots were delimited not according to zoning plans, but according to private parcelling parcelling. No owner, in order to maximize profit divides the land into individual plots, allocates land for common recreational areas (Polish law does not sanction this). Local governments only occasionally (usually due to lack of funds) buy out land for such investments. This is why cities lack playgrounds, outdoor gyms and squares for social interaction, which have become particularly important in times when enclosed spaces are banned.

The article is devoted to the rapid, flexible possibilities of restoring Polish towns (especially satellite towns) so that they are resilient and develop in a sustainable way, which ensures (also for future generations) balance of the built and natural environment, clean air, and good quality of living (including access to services, green areas and recreation). Some European cities have made a number of decisions to change their operations in the wake of the pandemic, for example in Berlin the city authorities took the opportunity to shift travellers from public transport and private cars to bicycles by creating temporary cycle lanes. As the pandemic intensifies and wanes, cities should adapt to the current situation and allow themselves some flexibility in their operations, including climate change. The paper adopts the term “pandemic resistant city”. The question is how such towns can be restored to ensure fast and cost-effective results of land-use changes, and whether we can prepare cities for potential pandemic and rapid regeneration in the post-pandemic period by properly shaping the functional-urban structure, using technologies of smart and soft cities, tactical urbanism and container city technology?

The article sets out two research hypotheses:

1. Cities in peri-urban areas show shortcomings in the development of service and technical infrastructure, in urban planning of cities (in terms of meeting the utilitarian, social needs of residents or the manager, with the simultaneous balanced use of natural conditions with ensuring full communication and technical service (Saternus, 2013, p. 361). These shortcomings are particularly due to changes in residents’ preferences during the pandemic.

2. Rapid remedial action is needed for satellite cities to ensure good living conditions so that they can become pandemic resilient cities. It is necessary to start transforming the functional structures of these cities towards “15-minute” cities, creating more local centres so that the walking zone does not exceed 1 km, multifunctional areas, good quality public spaces.

2. Great importance of green infrastructure, open spaces, neighbourly character and smart cities technology during pandemic process in Poland

The impact of historical epidemics and pandemic events on human history (Megahed and Ghoneim, 2020; Mir, 2020, pp. 94–108) on: society, economy, politics, culture, development of medical and technical sciences is well known.

The relationship between germ transmission and people-to-people contacts and social mobility (Giedroyć, 1899) has been noticed very quickly, which influenced the emergence of proposals for functional–spatial (Danowska, 2017, pp. 25–40; Burchardt and Burchardt, 2008, p. 337; Karpiński, 2000, p. 123). Pandemics reveal resilience or its lack in urban system (Banai, 2020, pp. 1–3), to threats resulting from poor hygiene and sanitation, inadequate service developments (Jabareen and Eizenberg, 2021) and growing social inequalities (Fabris et al., 2020, pp. 1–10).

Not only does the typical functional–spatial relationship change: work – home – services (Jalowiecki, 1967, pp. 215–216, 230–31), but also the way transport and public spaces are used, which can change social behaviours and habits for a long time (Fraenkel and Cho, 2020; Pratt et al., 2020; Weinig and Thierstein, 2021). Alter (2020, p. 1) wrote
about it:

“If more people were to work from home, neighbourhoods might spring back to life. Imagine a relaunch of Jane Jacobs’s [author’s footnote: Jacobs (1985)] urban ideal, where neighbourhoods have a diverse range of work and family functions, where municipal spending goes into parks, not urban expressesways, and where single-use areas, like clusters of downtown office towers, dead at night, become archaic”.

The location of undeveloped and green areas in the city structure is one of the tools for preventing the development of pandemic events, supporting the mental and physical health of residents and thus the vitality of the city (Abusada and Elshater, 2020, pp. 417–427; Capolongo et al., 2020, p. 13; Fabris et al., 2020, pp. 1–10; Geng et al., 2020, pp. 553–567; Herman and Drozda, 2021; Hobday and Cason, 2009; Klein, 2020; Pousou et al., 2021, pp. 2–10; Slater, 2020; Urgolini et al., 2020). Public green areas are also crucial for epidemiological restrictions, fulfilling not only the natural or ecological role, but above all the social role associated with health, recreation and the formation of social relations, as “places that may have once been relegated to passing through are now places for exercising, decompressing, and socializing at a safe distance — especially for those at greatest risk of isolation and infection (O’Connor, 2020, p. 1), and “the way we, in the post-pandemic world, rethink and reshape access to green infrastructure will be the greatest test of urban resilience.” (Herman and Drozda, 2021, p. 16).

It is also important to reduce environmental degradation and to combat climate change, which is correlated with an increase in disease (Lak et al., 2020, pp. 34–71; Moraci et al., 2020; Sharifi and Khavari-Garmssir, 2020; Shribman, 2020). The key factor for improving the quality of life in the city are also public spaces enabling social contacts, which “if safely and creatively reimagined, designed, and managed, can be community lifelines — for improving to essential resources, keeping people fit, and reducing isolation”, as evidenced by Jan Gehl’s survey on the use of public spaces during the COVID-19 pandemic, conducted in 68 countries (O’Connor, 2020, p. 10). Public spaces are also an important part of the re-opening during the abolition of restrictions and are now showing a new way of use, e.g. squares become local playgrounds and skate parks or bazaars, and boulevards, squares and parks places for spontaneous outdoor concerts, and places of social integration and physical activity (Gehl, 2020, pp. 37–53). The rethinking and redesign of public spaces is of economic and social importance, gives them the opportunity to operate in new sanitary conditions, which formulates the diversity of urban life and has a positive impact on economic aspects. Quoting Acuto (2020, p. 3): “Transport, public venues ranging from stadiums to cinemas and sites of prayer, and even streets might have to be retrofitted with the goal of avoiding overcrowding and service redundancy rather than continuous strain. (…) When the alternative is empty streets, quarantined urban dwellers, locked-down cities, a stalled economy, and most devastating of all, the loss of life, I argue we can no longer afford not to.”

In the literature on the subject, the authors draw attention to the diverse and efficient system of public transport, but also the priority of pedestrians and two-wheelers in the communication system: “(…) it seems individual transportation system will be one of the main choices; therefore, municipalities should prepare bicycles/electric scooters/motorcycle etc. friendly transport systems.” (Ahsan, 2020, pp. 281–285).

They also highlight the increased coverage of technical infrastructure and broadband technologies, the need to protect pedestrians and calming of traffic, and to widen pavements at the expense of roadways (Glas et al., 2006). It is important to create small ‘pocket’ public spaces (Whyte, 1980) at walking distance from one’s own home, described by urban planner B. Trodier as ‘hyperlocal’ (Roberts, 2020, p. 6). The concept of a 15-minute city is also an answer to sustainable and resilient development (Moreno et al., 2021; Hidalgo, 2020; O’Sullivan, 2020; Written, 2020), in which its neighbourly character is of great importance (Shuman, 2013; Oldenburg, 1999; Mitra et al., 2020) as well as social aspects (possibility of obtaining help, acquaintance with other residents) and functional-spatial aspect (short distances, mixed use design, walking distance, less pollution and noise).

Grassroots activities such as tactical urbanism (Bereitschaft and Scheller, 2020; Daly et al., 2020; Graziano, 2021; Jalan and Sen, 2020, pp. 105–124; Law et al., 2021, pp. 65–73; Morika and Rutum, 2020; Pakoz et al., 2021, pp. 1–16; Sepe, 2021, pp. 1–15) and soft cities, including temporary bike paths, private, semi-public and public back-yard greenery, café gardens, new public spaces, parklets, COVID-19 testing kiosks and mini-parks at the expense of road lanes or unused plots also turned out to be important. It is also important to be ready to create reserves of land for the construction of temporary hospitals, warehouses or shops (Lak et al., 2020, pp. 34–71). High resilience and assistance in preparing for the onset of epidemics is provided by smart cities, universal standards for data exchange and use, combined with artificial intelligence (Acuto, 2020, pp. 1–2; Abusada and Elshater, 2020, pp. 417–424; Ahsan, 2020; Allam and Jones, 2020; Elghenzawy and Elarabily, 2020, pp. 75–84; Söderström, 2020, pp. 1–9).

The preparation of pandemically resilient cities requires the involvement of specialists in many fields: planners, urban planners, engineers, politicians, urban authorities and scientists. Pandemic preparation protocols should become part of the city’s development strategy.

Lessons learned from the pandemic could bring new positive changes, as R. Banai (2020, pp. 8–10) wrote: “Pandemics, while exposing the vulnerabilities of the urban system, are also a driver of positive change in planning resilient urban form of the future”.

In order for cities to be resilient, they should achieve their objectives by introducing the following activities: tactical urbanism, smart cities, efficient and varied transport, pro-social and supporting local businesses, IT – water and sewage infrastructure. Residents used green and public spaces that became very important to them, e.g.: you could walk without masks, meet with friends, use the outdoor gym. The towns analysed are developed by single-family housing, in which there were no separate green areas, playgrounds or common spaces.

3. Material and methods

3.1. Study area

As a research area, the so-called Warsaw Capital Region¹ was chosen, whose external boundaries are determined by nine districts surrounding Warsaw. In this defined area there are currently (outside Warsaw) 22 small towns constituting municipal centres (population 4–30 thousand) and 9 medium-sized cities (population 30–60 thousand) which are the seat of the district authorities: Grodzisk Mazowiecki, Legionowo, Minsk Mazowiecki, Nowy Dwór, Otwock, Ozarów Mazowiecki, Piaseczno, Pruszków, Wołomin, which were selected for detailed research (see Fig. 1).

These cities, located about 20–40 km from Warsaw, are well connected with it by railway lines (Mazovian regional railways and high-speed urban railway of Warsaw), as well as by Warsaw’s public bus service (4 centres). Selected cities as service centres at county level should provide the necessary range of services for their residents, but also higher-order services for residents of surrounding municipalities.

The nine cities under study experienced their greatest development in the socialist era. The main factors of their growth were the proximity of Warsaw and a good railway connection, as well as workplaces (industrial plants, military centres). After the political transformation, the population growth dynamics of the analysed cities has been decreasing. The development structure is becoming increasingly dispersed, as

¹ 1.5 m distance between shoppers, 3 persons per 1 cash register in shops and service outlets, 20 m² per person in shops over 100 m². Marketplace – 3 customers per 1 retail outlet and 15 m² of space per person (source: https://www.gov.pl/web/koronawirus/kolejne-kroki, accessed 04/03/2021).
indicated by the low population density (Table 1). The highest increases in population occurred in Piaseczno and Ożarów, whose commune area borders Warsaw and is connected with it by efficient public transport (railways and municipal buses). Both cities have relatively low population densities, meaning they have plenty of potential land for development (Table 1).

The demographic structure of the studied towns is similar, with approx. 58% of inhabitants in the productive age and approx. 19–23% in the pre-productive age. However, the structure of the employed population is different, ranging from 14% of the total population (Legionowo) to 57% (Ożarów Mazowiecki). Most cities have a negative balance of commuting, i.e. more people commute than come to work, but comparing this data with the number of employed people one can say that on average 1/3 of people of working age do not work in their city of residence. The record-holder is Legionowo, where 77% of employed people commute to work, followed by Wołomin (46%) and Otwock (44%). These data support the view that these cities have become ‘dormitory towns’ for Warsaw (Table 2).

3.2. Methods of obtaining

The starting point for the research was the assumption that the earlier tendencies of increasing interest of potential inhabitants in properties located in smaller centres of the Warsaw agglomeration intensified as a result of the pandemic. The second assumption indicates that population growth in the study cities since World War II has not been commensurate with improvements in the quality of service infrastructure, especially services needed during the constraints of the Covid-19 pandemic.

Analyses of the spatial development of the cities under study in terms of essential basic services, use of means of transport (railway, bus, own car, bicycle), recreation and leisure areas. We conducted analyses based on: statistical data, spatial data and empirical data from field studies. Statistical data were obtained from the local data bank of the Central Statistical Office. We used these data to compare selected statistical indicators between cities. Spatial data were available free of charge through the download service from geoportal.gov.pl. For the analyses we used BDOT10k (it is an integrated copy of the Database of Topographic Objects, with content and detail corresponding to a topographic map in the scale 1:10 000) and high-resolution orthophotomaps from 2020. We also included POI data from GoogleMap and Open Street Map (OSM). Additionally, students conducted a field inventory in selected areas, which we also included. We integrated and organized the acquired spatial data into an ArcGIS ESRI geodatabase file. A geographic information system allows spatial data from different sources to be integrated and spatial analyses to be performed, so that new information can be extracted from the inputted data (Longley et al., 2005). In particular, network analysis is used in accessibility assessment (Abd El Karim and Awawdeh, 2020, Tang et al., 2021). Based on the collected spatial data, GIS network analysis (ArcGIS ESRI network analysis) was conducted to determine the service availability zones for walking distance of 300 m and 800 m. The areas of grocery stores belonging to major

![Fig. 1. Warsaw Capital Region against the background of Poland’s administrative division, with the location of cities selected for detailed studies marked.](image-url)
Stage 2

1) After carrying out the research from Stage 1 concerning the development of selected cities in the field of first necessity services, access to public greenery, active recreation areas, one most characteristic city with the largest number of inhabitants – Pruszków – was selected as a representative of a typical town located in the suburban zone. Retail, catering, recreation, and public services that are typically used daily or several times a week by residents were considered essential services. In Poland they are also called first degree services and should be located between 300 m and 500 m from the place of residence (Chmielewski, 2001, pp. 189–198, Chmielewski, 2016 pp. 281–285).

2) Development morphology was prepared for Pruszków on the basis of the BDOT10k database showing the types of buildings and orthophotomap. They also used the street view in GoogleMap to estimate the portion of the building occupied. The sales area was taken as 70% of the estimated store area.

3) For the entire urbanized area of Pruszków, a diagnosis was made of pedestrian accessibility (the assumed distance is 800 m) to the most important services, public greenery and active recreation areas.

4) In cooperation with students of Spatial Management at the Warsaw University of Technology, 48 projects were carried out for designated various "urban voids", where functions proposed by residents could be introduced to fill in the gaps in times of pandemic, using the following methods: tactical urbanism and temporary modular construction.

Table 1
Analysis of the demographic changes of the studied cities from 1946 to 2019.

| Study area    | per/ha 1946 | 1980 | 1992 | 2012 | 2019 | od 1946 | 1992–2019 |
|---------------|-------------|------|------|------|------|---------|------------|
| 1 Grodzisk Maz. | 24          | 14610 | 23237 | 24800 | 28329 | 32125   | 65%        |
| 2 Legionowo    | 40          | 8884  | 34239 | 50000 | 54170 | 53886   | 506%       |
| 3 Mińsk Maz.   | 31          | 10023 | 27593 | 34500 | 38697 | 40999   | 173%       |
| 4 Nowy Dwór    | 10          | 5046  | 21403 | 26900 | 28360 | 28679   | 173%       |
| 5 Otwock       | 10          | 12592 | 47086 | 43200 | 44487 | 44636   | 198%       |
| 6 Ożarów Maz.  | 14          | 2291  | 6956  | 7100  | 8848  | 11938   | 421%       |
| 7 Piaścicno    | 29          | 6579  | 22808 | 24500 | 42295 | 48450   | 636%       |
| 8 Pruszków     | 32          | 25096 | 48483 | 52900 | 56929 | 62317   | 148%       |
| 9 Wołomin      | 22          | 8296  | 29830 | 36400 | 37112 | 37056   | 182%       |

Explanations:
- population growth.
- population decline.

The following periods of analysis have been assumed: 1946 – the period after the war; 1980 – the beginning of the economic crisis in Poland, as a result of which the growth of cities slowed down; 1992 – first statistical data after the political transformation.

Table 2
Demographic analysis in the study cities by working age and commuting in 2019.

| Study area    | 2019 Employed (of total) | Commuters | Coming to work | Total |
|---------------|--------------------------|-----------|---------------|-------|
| 1 Grodzisk Maz. | 32125 | 35,6% | 11436 | 3117 | 27% | 3005 | 112 |
| 2 Legionowo    | 53886 | 14,2% | 7652 | 5909 | 77% | 1422 | 4487 |
| 3 Mińsk Maz.   | 40999 | 27,5% | 11275 | 4023 | 36% | 2953 | 1070 |
| 4 Nowy Dwór    | 28679 | 32,3% | 9235 | 2555 | 28% | 1644 | 911 |
| 5 Otwock       | 44636 | 21%   | 9374 | 4096 | 44% | 3084 | 1012 |
| 6 Ożarów Maz.  | 11938 | 57,1  | 6817 | 1077 | 16% | 791  | 283 |
| 7 Piaścicno    | 48450 | 40,3  | 19530 | 1850 | 10% | 12011 | 10161 |
| 8 Pruszków     | 62317 | 28,9  | 18010 | 6132 | 34% | 4442 | 1690 |
| 9 Wołomin      | 37056 | 22,9  | 8486 | 3925 | 46% | 3549 | 375 |

Explanations:
- positive balance of commuting (more people arriving than leaving for work).
- negative balance of commuting (less people arriving than leaving for work).

Retail chains were also designated. Shops were located on the basis of obtained addresses and their approximate area was determined on the basis of BDOT10k topographic data (object class BUBD buildings) and orthophotomap. They also used the street view in GoogleMap to estimate the portion of the building occupied. The sales area was taken as 70% of the estimated store area.
4. Results

4.1. Results of surveys carried out among the inhabitants of the examined towns

The purpose of the survey was to gather information from the residents, of the selected villages, on the quality of life in the era of the Covid-19 pandemic. The questions dealt with changes in the way of life, accessibility of services, communication and greenery, as well as residents’ opinions on modular facilities, functions for these facilities, which can be located on unused land. The survey was conducted online, it was a one-time survey, both closed and open-ended questions were used. The pilot survey, completed by 312 people, had a regional scope, and was a random sample type. The minimum size of the research sample is 200 people (Bazarnik J., Grabiński et al., 1992), so it was considered to be a small group of respondents but showing the opinions of the regional population. The survey discussed here can be used to conduct another deeper survey as a further research process. Among the respondents there were both people with higher education (almost 73%) and secondary education. The group of respondents was dominated by women, as much as 61%. The survey was conducted among the residents of the surveyed villages. The largest number of people, 39%, who took part in the survey, came from Grodzisk Mazowiecki, the smallest share was held by the inhabitants of Otwock, 2.5%. Responses to the questions were consistent regardless of the area in which the respondents lived. The age of the respondents ranged between 18 and 65 years. The largest number of respondents were 26–35 year-olds (35%) and 36–45 year-olds (32%). The survey began on January 25 and ended on February 7, 2021. The study was divided into several parts:

1. shopping
2. communication
3. leisure and recreation
4. what problems have increased in the era of the pandemic?

Re. 1) In the shopping section of the survey, respondents answered 5 questions. The answer to the question "How often during a pandemic do you shop for necessities (dairy, meats, vegetables, fruits, fish, etc.)?" is interesting. It was noted that the pandemic has not affected the change of previous habits and shopping is done with a frequency of once a week or once every few days. Among the respondents, 56% shop at a big-box store, while 32% shop at a small supermarket (Fig. 2). A slight increase of 6% can be observed in shopping in a local store and an increase of 5% in basic purchases in a big-box store. One can see a reduction in shopping in a small supermarket in the pandemic era compared to before the pandemic. At the same time respondents were asked where they would prefer to do their shopping, if they had the opportunity, in times of pandemic, the marketplace (bazaar) gains from 8% to 12%, the neighbourhood store from 18% to 28%, at the expense of the big-box store and the small supermarket (Fig. 2). Such trend shows, however, that shopping tendencies have slightly changed, as there are no small neighbourhood shops and markets nearby. Respondents would prefer to use markets and shops if they had the opportunity. Since they do not have it, they choose to shop once a week or every few days at a big-box store because it provides a bigger space and better comfort among shoppers than a small supermarket, as well as a larger assortment of goods, allowing you to do one-stop shopping.

Re. 2) In the transport part, 5 questions were asked about the way of getting around the city, going to work, residents’ preferences regarding the means of transport (Table 3). There has been a decline in the use of public transport by residents in favour of individual transport, the car (used more often by 39% of respondents). When it comes to walking or cycling, there has been no change in habits.

Re. 3) In the leisure and recreation section, 2 questions were asked about the use of public green spaces and sports and recreation. More than half of the residents indicated shortage of these services, but at the same time 47% of respondents use such areas less often. Also, no change in habits was shown for the use of sports and recreation areas (more than 50%) in connection with the pandemic. This situation may be due to closed sports grounds in times of pandemic, but also to the lack of a proper place for physical activity in the lives of residents. More than half

![Fig. 2. Chart showing responses to questions about shopping in the era of the pandemic.](image-url)
of the respondents felt there was a lack of access to sports and recreation areas (151 people out of 312 who took part in the survey), the second service that residents also felt a shortage of culture (cinema, theatre, museum), (Table 4).

Re. 4) In the answer section “what is the city like in the age of the pandemic? Problems of the city in the age of pandemic” 7 questions were asked, which were open-end questions (Fig. 3). According to the Respondents, the biggest problems for cities in the pandemic era are:

- poor air quality
- increase in the number of stores being closed
- increased car traffic,
- increase in the number of stores closed down due to bankruptcy,
- lack of parking spaces in the central part of the city,
- inefficient public transport, too low frequency of buses,
- not enough green and recreational areas
- lack of well-developed cycling infrastructure,
- lack of comfortable wide sidewalks,

Questions were also asked about the use of temporary modular housing to supplement missing infrastructure and the functions that could be introduced into such facilities. Respondents have very different attitudes towards temporary housing, some of them considered the introduction of such facilities as right, while others are against this form (Table 5).

4.2. Towns in the pandemic era

4.2.1. Essential services

During the epidemic emergency and subsequent lockdown periods, residents’ preferences for using necessities changed slightly, as evidenced by survey research. Residents are more likely to do their daily shopping at local stores (usually grocery and drug stores) near their place of residence, but the problem is that there is often a shortage of these establishments. After the transformation of the political system in Poland, the structure of retail trade changed and the era of centralization of trade in large chain supermarkets took place, often located close to the central zone, which became too much competition for smaller, private outlets and resulted in the fact that a significant part of small retail trade ceased to exist. In the era of the pandemic, some of the large-format facilities were temporarily closed, some were operating, but by limiting the number of users, doing the shopping required long waiting outside the facility, which was quite an inconvenience. In the era of the pandemic, there has been a great reduction in the access of residents to shops. It resulted from the introduction of limits on the number of persons per sales area. According to the authors’ calculations, such restrictions have led to difficulties in accessing essential services (Table 6). If all residents wanted to shop every day there would be a deficit of retail space in the eight cities studied, resulting in queues outside grocery stores. During the average time of year, shopping tends to be done with less frequency (1–2 per week according to the survey), but then the hourly shopping time should be assumed, which will potentially reduce the opportunities to meet needs. Assuming an even distribution of shoppers per week (6 days of operation) then the stores should be able to serve approximately 16% of residents. This is provided in all cities. However, most people prefer weekend shopping, which means an accumulation of shoppers. In this situation in Ożarów Mazowiecki, Otwock, Piaseczno there may be queues in shops posing a risk of infection. For many people, supermarkets are also seen as dangerous zones with a risk of contagion. Markets are experiencing a renaissance, but located on too small surface, they limit the number of sellers and buyers (Table 6). This situation is improved by spontaneous, informal markets, located on free squares and in parking lots outside supermarkets.

4.2.2. Communication and transport

All analysed cities have urban public transport, usually based on city buses. These towns are located at a distance of 20–40 km from Warsaw (Fig. 4), therefore access to the capital is guaranteed by buses and trains. The examined cities have a common ZTM ticket with Warsaw, eight of them are located in the second ticket zone, while only Nowy Dwór Mazowiecki is outside its scope.

In this pandemic era, there has been a noticeable decline in the use of public transportation, in favour of individual commuting to work, the office or the store. Government-imposed restrictions and fear of contagion have resulted in a decline in the use of urban transport and a gradual increase in individual car transport (for Australia, generally across all cities: Munawar et al., 2021; Spain - one city: Aloï et al., 2020). In the literature on the impact of Covid-19 on public transport, Gkioulalis and Cats (2020) reports that the number of public transport passengers at the peak of the virus dropped significantly by 50–90%. It is conjectured that the attractiveness of remote working, even after the pandemic has abated, may result in lower urban transport use (based on a study in metropolitan Sydney: Hensher et al., 2021). However, this is not the case for workers in basic jobs, which may deepen social inequality (Hu and Chen, 2021).

In the surveyed cities, three urban zones were noted:

- The centre is usually located near a railway station;
- The intermediate zone, where complexes of multi- and single-family housing estates from the socialist era are located;
- The outskirts, interspersed with fallow land, where scattered single-family buildings are located, most often as detached houses.

Residents living in the city centre and surrounding multi-family residential zones can take advantage of many essential services or so-called essential services (education, health, culture, sports and recreation, retail and catering). In general, as one moves away from the city centre, car ownership becomes more necessary due to the dispersion of development zones, counting from the city centre, requiring longer commute times to activity sites and increasing distances to transit stations (Basu and Ferreira, 2021). The phenomenon of availability of services was presented in graphic form on the example of one of the 9 cities under analysis - Pruszków (it is the most populous city where the analysed phenomena are most typical in relation to the remaining ones (Fig. 5)).

In the surveyed cities, residential zones are located even at a distance of about 3 km from the service centre, which results in frequent use of the individual car as a means of transport. The reason for this situation is primarily, the lack of increased frequency of buses and trains (see respondents’ answers in the surveys) during the period of COVID-related restrictions. Residents were opting out of this form of commuting for fear of being too close to other users. This situation is illustrated by the increase in the number of passenger cars in cities, especially in communal areas (data on the scale of county of the surveyed cities, according to the Polish Statistical Office, are shown in Fig. 6). Trends in the increase of the number of passenger cars per capita are observed throughout Poland (increase by 36% in 2010–2019). These indicators are significantly higher than in other European countries (e.g. United Kingdom, Spain, Germany, Finland) (www.eurostat), which have seen

| Services in deficit | culture | retail | catering | sports and recreation | crafts | all together |
|---------------------|--------|--------|----------|-----------------------|--------|--------------|
| Which services do you think were most in deficiency during the pandemic? | 83 | 26 | 18 | 151 | 18 | 16 |
only a slight increase in the number of cars in recent years. Another travel-related aspect analysed is bicycle transportation. In Poland in the last 10 years there has been a change in the way of life, residents more often commute to work by bicycle, scooter or motor-cycle. Thanks to the EU subsidies, the construction of bicycle paths is noticeable, with an increase recorded in all the analysed cities. For example, between 2012 and 2019, the length of paths increased twofold in Legionowo and fivefold in Nowy Dwór Mazowiecki and Pruszków. The development of cycling infrastructure increases the number of cyclists, as potential users prefer safe paths to roads without cycling infrastructure.

An increase in the number of cars correlates negatively with an increase in pollution, which contributes to poorer air quality. Reducing air pollution can contribute to controlling the spread of the pandemic and increase coping capacity of the infected individual. Several studies have found strong associations between COVID-19 transmission/mortality and high levels of air pollution. (Bai et al., 2020; Coccia, 2020; Sharifi and Khavarian-Garmsir, 2020; Xu and Li, 2020; Yao et al., 2020). In the case of gaseous pollutants there is a decrease, but not significant (Mińsk Mazowiecki, Nowy Dwór, Piaseczno, Pruszków, Wołomin).

4.2.3. Recreation and leisure (leisure time)

Green areas in the city have both social and natural functions, have a soothing effect on the well-being of residents, and improve the quality of life of residents. The more green areas there are per capita, the greater their accessibility and the closer they are to the place of residence. In times of pandemic, access to public green spaces, has become more important for social reasons, as “contact with nature provides us with many intangible benefits and can act as a protection against the negative consequences of lockdown measures in mental health. Maintaining contact with nature (blue-green spaces) during COVID-19 lockdown was found to reduce

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**Table 5**

Respondents’ answers to questions about temporary change of land use, own study.

| Questions                                                                 | Yes | I don’t know | No | Suggested functions |
|--------------------------------------------------------------------------|-----|--------------|----|---------------------|
| Is a temporary change of land use a good idea in your opinion? Justify your statement. | 35  | 15           | 13 |                     |
| Do you think that temporary buildings (shops, medical points) offer an opportunity to improve the living conditions of residents in the time of a pandemic? What kind of function do you see in such buildings? | 174 | 78           | 60 | hospital, clinics, small services, commerce, customer service, meeting place, schools, kindergartens, catering, |

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**Table 6**

Number of supermarkets and markets in the analysed cities in 2019.

| Area of analyses | Number of residents | Number of residents | Number of residents | Number of residents | Number of residents | Number of residents |
|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Grodzisk Maz.    | 32,125              | 13                  | 10,740              | 5                   | 11865              | 33,908              |
| Legionowo        | 53,886              | 13                  | 12,875              | 9                   | 2040               | 22,373              |
| Mińsk Maz.       | 40,999              | 13                  | 13,850              | 12                  | 2055               | 23,858              |
| Nowy Dwór        | 28,679              | 9                   | 12,765              | 3                   | 588                | 20,030              |
| Otwock           | 44,636              | 10                  | 8610                | 10                  | 1770               | 15,570              |
| Ożarów Maz.      | 11,938              | 1                   | 950                 | 7                   | 1120               | 3105                |
| Płaszczno        | 48,450              | 9                   | 10,785              | 17                  | 2395               | 19,770              |
| Pruszków         | 62,317              | 13                  | 7125                | 14                  | 9289               | 24,621              |
| Wołomin          | 37,056              | 8                   | 11,325              | 10                  | 1571               | 19,344              |

Explanations:
1. Number of large-format stores (over 400 m²), 2. Area of large-format stores 3. Number of retail stores with a floor area of 100–400 m², 4. Total area of stores in columns 2 and 4; 5. Theoretical number of residents able to shop in a pandemic regime per day; 6. Percentage of residents able to use stores during pandemic restrictions per day; 7. Number of markets/space, 8. Number of people per market.
the likelihood of reporting symptoms of depression and anxiety” (Pouso et al., 2021). Within the surveyed cities, there are areas of developed greenery (e.g. parks, squares, greens), as well as forests and considerable areas of agricultural land (mostly fallow) in the fringe zone. Unused areas become particularly important during periods of temporary closure as they could serve as pedestrian recreation (walking) areas.

In each of the examined cities (Table 7) there are “indoor” sports facilities (sports halls and swimming pools) which were closed down in the time of the pandemic, which led to an increase in demand for sports places located outdoors such as outdoor gyms (from 5 to 16 in the analysed cities), jogging paths, playgrounds, skate parks (most often there are 1 or 2 in a city). Playgrounds generally accompany multi-family developments, but among single-family housing complexes there are no meeting places for children who have been “imprisoned” in their homes and do not attend school or kindergarten. There is also a lack of children’s clubs for young children.

The area of public greenery is diversified in the structure of the analysed cities. It consists of walking and recreational parks, residential green areas, squares (greens) and street green areas. The largest number of green areas is located in Otwock (a former health resort) and Piaseczno, and the smallest in Ożarów Mazowiecki. Data showing the areas of such areas are shown in Fig. 7. The average area of public green areas per inhabitant in the analysed cities is approximately 15 m². The average indicator of public greenery per inhabitant in the twenty-six largest Polish cities is approximately 24.5 m² (based on data from the Polish Statistical Office), which means that these cities do not have sufficient green infrastructure.

4.3. Tactical urbanism as a tool to repair cities to make them better to live in times of pandemic threat

During the winter semester of the 2020/21 academic year, students of the Spatial Management engineering course at the Warsaw University of Technology analysed and diagnosed the building development status of selected cities in terms of improving the quality of life in times of pandemic. At the first stage, they analysed the building development morphology for each city, determining its types: compact multi-family developments in the centre, semi-compact multi-family developments (housing estates), mixed multi-family and single-family developments, clustered single-family developments (estates on a regular grid of
streets), and dispersed single-family developments (extensive). In all cities, the dominant building development was single-family housing, of which about 5–15% was extensive. Based on the analysis of land use, the land occupancy indicator was determined, which showed how much of the land is undeveloped (exemplary data for Pruszków are presented in Fig. 8 and Table 8). At a further stage, ‘empty’ urban plots were mapped in the surveyed cities and proposed for temporary investment, with the services that residents wished in the surveys (especially in unserviced areas), creating such spaces and facilities that are missing in the city. The possibility of buying/leasing these plots was assumed. Methods known from trends: tactical urbanism and temporary modular construction (container city) were proposed as a method of their development.

As part of 48 works made by students, various solutions using the construction of temporary (container) facilities were proposed: (a) workplaces: “boxes” for rent with Wi-Fi access, (b) container spaces for a club and café, (c) work rooms, (d) healthcare facilities with vaccination areas, (e) catering facilities with takeaway products and outdoor gardens. The need for social interaction and a change of environment was also recognized and this could be realized by residents on the basis of cinema screens, dog parks, picnic spots, a small basketball court, a place for tennis tables, or places for remote outdoors work with wi-fi access and comfortable urban furniture e.g. benches with proper backrests, tables and canopies. It was important to adapt public spaces to the new sanitary conditions, such as public toilets, hand sanitizers, and adequately wide sidewalks.

The projects have paid attention to pro-ecological solutions, such as introduction of new local green areas, new trees etc. With the outbreak of the pandemic, the volume of stored waste has increased in residential developments with the rise of online shopping and food orders from deliveries. Therefore, it was proposed open composters and new forms of waste storage. In many projects, proposals have emerged for cycling infrastructure popular in the era of the pandemic: new bicycle parking lots, service stations, or bicycle paths that would connect residential areas and functionally important areas such as concentrations of services and commerce. A selection of 4 design concepts is shown in Fig. 9.

5. Discussion

Towns around large centres (such as those selected for the study) should form a polycentric settlement network of ‘15–30 min cities’ which are not only places to live but have a good economic base (jobs). They should provide access within walking distance to basic frontline services, including commerce (Oldenburg, 1999) and green spaces (Crosbie, 2020), and also allow for the activation as a recreational base of post-agricultural, currently neglected, open spaces, the so-called ‘third landscape’ (Gilles, 2004, p. 3). It is also important to reactivate agricultural functions in these areas (Kunstler, 2005, p. 255).

Analyses of the development of the cities studied show many shortcomings in terms of “resilience” to the challenges posed by the pandemic. During the lockdown, when many workers were forced to do their work online, in their own homes, shopping and leisure preferences changed. For reasons of reduced commuting, it would be best for residents to be able to access essential services close to where they live, within walking distance. In order to achieve such an effect a city should be characterized by a compact structure with a high population density (Barton et al., 1995, pp. 353–358.). Such trend will help reduce greenhouse gas emissions (Newman and Kenworthy, 1989, pp. 24–37), as each doubling of the average for the study area can result in a 20–40% decrease in...
household vehicle use and per capita gasoline consumption (Gottdiener and Budd, 2005). The most important functions in a small and medium-sized city or settlement should be within walking distance of about 800 m (Barton, 2017, p. 87). A public transport stop (up to 400 m), a primary school (800–1000 m), a local centre, a pub, a small park, a recreation complex (300–600 m), a health clinic (800 m) should be located in the immediate vicinity (Barton et al., 2010, p. 25).

According to the surveys carried out on the living conditions in the city and the problems that occurred in connection with the Covid-19 pandemic, one can notice, first of all, the changes in the way of movement of the population and shopping for essentials. With the outbreak of the pandemic, residents also felt the lack of the access to service facilities (swimming pools, fitness clubs, gyms) for sport and recreation that would allow safe use (low density of users). In particular, there is a lack of sufficient ‘outdoor’ facilities available at lockdown time.

The biggest observed change in the organization of daily life of the residents is the shift away from public transport to individual transport, which is mainly due to fears about their health, but also working and studying remotely in one’s own home, which reduces the need to travel. It is noteworthy that among the biggest problems of cities in the era of the pandemic, residents cited a number of issues related to transportation - frequency of courses and increased traffic on the streets. In the surveyed cities, only the central zone is well served with services, unlike the suburban zone. Residents usually use their own cars to commute to service establishments to meet essential needs (to get to the store, market, office, pharmacy). They prefer this mode of transport, in
fact they are “condemned” to it because there are no services within walking distance from their place of residence and public transport does not reach everywhere. The increase in passenger cars translates into increased air pollution (one of the problems noted by residents in the survey). At this stage, it is unknown whether the pandemic crisis will have a long-term impact on changing the public transport system. Past experience suggests that large-scale crises, such as the energy crisis of the 1970s, the 9/11 terrorist attacks in the United States, and the SARS outbreak in the early 21st century, have not fundamentally changed travel patterns, but have led to innovation and changes in security. According to a study by Gkiotsalitis and Cats (2020), at the height of the virus, the number of public transport passengers dropped between 50% and 90% (in China, Iran, USA), making this sector one of the most affected by the pandemic. Although a decrease in pollutant emissions can be observed in the examined cities, which is most often the result of changes in the method of heating residential houses, elimination of coal stoves in favour of gas and electric ones and introduction of ecological heating methods (photovoltaic panels, heat pumps), the increasing share of automobile transport in internal journeys of the inhabitants may undermine this improvement. These negative effects are also strongly influenced by the dispersed development of the surveyed cities (as indicated by their low population density). According to Gottdiener and Budd (2005, p. 153), per capita gasoline consumption decreases with city density, and any doubling of the average population density of the study area can result in a 20–40% decrease in household vehicle use, which will correspondingly decrease GHG emissions.

According to residents, another important issue affecting the quality of living is access to green areas, especially well-developed ones enabling physical activity and walks. In the surveyed cities the area of such zones and the number of devices enabling outdoor activity is too small. For example, according to Howard (2009), p. 171, in a “garden city” located in a suburban zone, the area of green space (parks) should be about 250 acres (about 101 ha, or about 32 m² per capita) (Majewska et al., 2020). The analysed cities, which are located around Warsaw like Howard’s garden cities, could claim this title, as they have around 12–21 m² of park and recreational greenery per capita. Large areas of former farmland in the fringe zone or the banks of local rivers (known as third landscapes) could fill this gap, but the lack of legislation governing ownership in these areas makes them unattractive for walking due to spontaneous scrub.

One way to improve the pedestrian accessibility of pandemic essential services, and consequently improve the quality of life for residents, is to introduce temporary, modular housing on undeveloped, vacant lots that can be temporarily converted. It is important to well

Table 8  
Example occupancy coefficients of urbanized areas (Pruszków city) for particular morphological zones of development depicted graphically Fig. 9.

| Morphological types of buildings | Zone area (ha) | % of zone area in the city area | Invested area within the limits of the plots (ha) / buildings (%) |
|---------------------------------|---------------|---------------------------------|---------------------------------------------------------------|
| 1 Compact multi-family housing (downtown) | 11,99 | 0,63 | 4,14 | 34,53 |
| 2 Semi-open multi-family housing (estates) | 110,49 | 5,76 | 21,34 | 19,31 |
| 3 Mixed development (single-family, multi-family) | 153,46 | 8,01 | 25,84 | 16,84 |
| 4 Single-family clustered development (estates on a regular grid of streets) | 341,54 | 17,82 | 42,35 | 12,4 |
| 5 Dispersed single-family housing | 129,5 | 6,26 | 14,58 | 11,26 |
| 6 Non-residential buildings | 422,24 | 22,03 | 78,33 | 18,55 |

Source: student study under the direction of the authors of the article. Students: Buraczynski Robert, Dębowska Hanna, Dziurdzia Weronika, Dolata Anna, Gomola Dominik, Izdebski Maciej

examine the need for functions that can find a location in such buildings and to determine the place for the location of such facilities. Studies on the morphological structure of urban developments and land occupancy coefficients (e.g. for Pruszków Fig. 6) allowed for the selection of undeveloped plots. These plots may be owned by the municipality, but may also be privately owned. Many plots of land in cities were bought for speculative purposes, or inherited as a result of inheritance divisions and remain sometimes many years undeveloped. For their temporary development (e.g., modular housing, recreational activity areas), a form of pandemic leasing of these plots or exemption from land taxes in exchange for the ability to lease could be used, which would also benefit the owners. Residents in the survey were asked about designating a function for such temporary modular facilities. They have proposed additional mini-health clinics, kindergartens and school divisions (allowing the current overcrowded facilities to be thinned out), food outlets (take-away food), and outlets with accessible essential products. The research was conducted by analysing the 3 main pillars of urban development in the era of pandemics, which were indicated as priorities by the respondents of the surveys. There have been no social studies affecting the different population groups of the city (poverty, wealth, age). The possibility of activating the city through new IT technologies (smart city) and pro-environmental solutions was not mentioned. To complement the survey results, the morphology of the street system should be examined, including sidewalk widths and access to bike lanes. For smaller towns, statistics are lacking and field research would need to be conducted, which can be done later in the study. Nevertheless, the studies initiated show the necessary directions for the transformation of cities to become better for living.

6. Conclusions

The COVID-19 pandemic had a significant impact on the functioning of Polish cities, especially those located in the agglomeration of the capital, Warsaw. Aiming to bring the pandemic to an end quickly and effectively, city authorities, urban planners, architects, academics, and local communities are working hard to understand the transformation of cities in the pandemic era and reflect on their future in the post-pandemic period. The authors of the article through the performed research confirmed the research hypothesis. The deficiencies in the development of service infrastructure, evident due to changes in residents’ preferences in times of pandemonium, have been demonstrated. It has been analysed how a pandemic may affect the functioning of Polish cities located in agglomerations of large centres. An attempt was made to determine what factors are crucial for the transformation towards a pandemic resilient city in Poland and what actions in the functional-spatial category are needed to protect and prepare cities for potential future epidemiological threats. The analysis of international literature, statistical research, analysis of changes in the real estate market, interpretation of GIS (Main Sanitary Inspectorate) spatial data and survey research showing the changing needs of residents in the era of the pandemic allowed us to define the possibility of introducing potential long- and short-term remedial solutions.

In the course of the study, aspects important for a good life of the inhabitants of Polish cities in the era of the pandemic were pointed out. The proposed solutions for temporary development of ‘empty’ plots could in a ‘low-cost’ way improve the quality of living in the city and be a tester of the usefulness of such solutions as a target form, which is characteristic for tactical urbanism. At this moment Polish cities do not have funds for purchase of land (often so called ‘flea remains’ of plots, divided as a result of building road infrastructure). EU funding for post-pandemic reconstruction offers new opportunities, which could improve the quality of life in cities by adapting their development to the new needs of their inhabitants. Such actions would increase the ‘resilience’ of cities to current and future pandemic threat challenges.

It is advisable to introduce monitoring of urban transformations not only in Poland, but also in Europe and what should be done to make...
cities resilient. The applied methodology can be implemented in many European cities, regardless of their size and location within the country.

Conflicts of interest

The authors report no conflicts of interest.

Data availability

The data are available on request from the corresponding author.

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