

Settlement size and the location of primary schools in Poland

Abstract

This paper draws on detailed demographic and educational data from over 42,400 localities and 13,100 schools in Poland to examine the occurrence and size of schools in different locality size classes. The findings indicate that the presence of schools in smaller localities is closely related to population size, particularly within the 400–700 inhabitant range. The study also shows that average school size is statistically associated with locality size – up to a population of 4,100, roughly. Beyond this threshold, primary school sizes and school size structures tend to be similar across localities of different sizes. The research results confirm that population and settlement conditions are important factors in the functioning of education in small localities, while also suggesting that school networks in large villages and small towns can be optimized with size parameters similar to those found in large cities.

Keywords

Primary schools • geography of education • school networks • settlement network • Poland

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Introduction

The relationship between the spatial distribution of schools and that of the population is among the most frequently addressed topics in geographical and educational research, and one with the longest-standing tradition. In Poland, the first studies of this type took place in the interwar period (Falski 1925). These early investigations primarily sought to understand the factors influencing the location of schools and the decisions shaping the so-called school catchment areas (areas administratively assigned to schools, from which their students are recruited) in various spatial contexts (local and regional). Even in these early analyses, there was a clear effort to identify broader spatial patterns through the use of tabular and cartographic compilations on a regional and nationwide scale. In subsequent decades, this line of inquiry evolved into a wider trend of quantitative geographical and educational research (see Meusburger 1998; Bajerski 2014). Over time, however, this was gradually replaced by more in-depth qualitative approaches focusing on local societies, children and their families, and local and state educational policies (see Holloway & Pimlott-Wilson 2012; Kučerová et al. 2020a).

Currently, quantitative research on school distribution focuses on several issues. The first are the analyses conducted in the tradition of operational research, focused on optimizing the distribution of schools in a given area in relation to the distribution of the population, assuming the minimization of the costs of operating the school network (including transport costs; see Mattsson 1986; Nikolaev & Egorov 2022; Al-Sabbagh 2022, Han et al. 2023), or optimizing the transport of students to schools (Meena et al. 2022). In their research, some authors explicitly assumed the need to search for a possible spatial equilibrium in the distribution of schools (Yan et al. 2018), as well as the pursuit of educational equity in two main aspects: accessibility equity and quality equity (Wang et al. 2021).

In recent years, more and more research has been devoted to the distribution and accessibility of schools in rapidly urbanizing areas – in particular, the growing mismatch between the location of schools and the distribution of the population in large urban agglomerations (see Walaszek 2016, 2019; Tanveer et al. 2020; Wu et al. 2020; Zhang et al. 2021; Jiang et al. 2022). At the same time, research is still being conducted on the location of schools and their accessibility in the light of the rural–urban divide (Guo et al. 2020; Xu et al. 2022; Xiang & Stillwell 2023) and the increasing number of countries with depopulation processes (Bahrenberg 1981). The universality of these processes, in turn, translates into the frequently discussed topic of school closures, leading to numerous studies trying to identify, on the one hand, the impact of the demographic and non-demographic factors of school closures at various spatial scales (Haartsen & Van Wissen 2012; Kučerová & Kučera 2012; Lehtonen 2021) and, on the other, the impact of school closures on the populations in the localities in which they are located (Barakat 2015; Sørensen et al. 2021; Sageman 2022). This reflects the repeatedly demonstrated high importance of the local school for the local community (see Witten et al. 2001; Hargreaves 2009; Kearns et al. 2009; Autti & Hyry-Beihammer 2014).

Although studies devoted to the above issues are numerous, there is a lack of more basic research – namely studies aimed at capturing general relationships in the occurrence of schools and their essential characteristics, the results of which could constitute a context for many subsequent studies using various methodologies and solving problems at various spatial scales. One such fundamental issue is the relationship between the size of the locality (number of inhabitants) and the presence of primary schools and their size (number of students).

On the one hand, this relationship seems obvious and well known – the size of the locality is the essential determinant of the

location of schools since it usually translates quite proportionally into the number of school-age children (Piwowarski 1992, 2000). Localities with a certain minimum number of inhabitants, regardless of the characteristics of the surroundings, provide a sufficient concentration of potential students to make the school located there large enough to be financially effective (with the appropriate number of classes). The existence of schools in smaller localities is usually the result of other factors – in particular, the lack of larger villages and towns in the area, low population density, dispersion of settlements and, finally, local and national educational policy, leading to the creation of school catchment areas that include many localities (Piwowarski 1992; Bajerski 2021; Kramer & Jahnke 2019). The above conditions vary significantly across spaces, which may lead to different relationships between the size of the localities and the presence of schools in different areas within one educational system. Tracing and understanding these relationships is important because the presence of a school in a locality influences, among other things, the position of the locality in the settlement network and the quality of life of its inhabitants. It is especially noticeable in the case of the closure of schools in rural areas, which is often accompanied by, among other things, a reduction in the frequency of public transport and the collapse of some commercial establishments (see Kučerová 2012; Mandujano et al. 2012). In addition, due to the unique culture-forming role of schools in smaller localities, social bonds between residents, previously cemented by meetings at or related to school, may be eroded (see Bell & Sigsworth 1987, 1992; Witten et al. 2001; Oncescu & Giles 2012; Autti & Hyry-Beihammer 2014).

The size of the school, in turn, is often treated as one of the essential variables that increases the risk of various forms of violence and of disturbing the generally accepted social norms (Leung & Ferris 2008; Johnson 2009; Gottfredson & DiPietro 2011). Additionally, some studies indicate a decline in the average educational results of students as the school size increases (Kuziemko 2006) and an improvement in results in some subjects in small schools (Lee & Loeb 2000). Other studies have shown the negative impact of school size on the educational outcomes of specific categories of students – for example, students with learning disabilities (Gershenson & Langbein 2015), while still others did not confirm such relationships (McMillen 2004).

The aim of the article

The aim of the article is to examine the relationship between the size of a locality and both the presence and the characteristics of primary schools in Poland. The study seeks to answer the following research questions:

- 1) What is the distribution of schools across localities of different population sizes, and is there a specific threshold or range of locality sizes that can be considered crucial for the presence of primary schools in Poland?
- 2) How strong is the relationship between the school and the locality size, and within what population range is this relationship statistically the most pronounced?
- 3) Can localities be effectively grouped into size classes that exhibit similar school size structures?

While these questions may appear self-evident in the context of the provision of primary schools across localities of different sizes, they remain largely unanswered – not only in Poland but also in many other countries. Addressing them is important not only for academic purposes but also for practical ones. Understanding the statistical relationships between the presence and the characteristics of schools and the size of the localities is essential for designing effective and spatially equitable mechanisms for the financing of education.

Data sources and research methods

In the Polish education system, a primary school (szkoła podstawowa) is an eight-grade institution offering compulsory education for children aged seven to fifteen. Statistical information on primary education in Poland is available both in the form of aggregated data for administrative units, contained in the online Local Data Bank of Statistics Poland (2022), and of reports from the Educational Information System, run by the Ministry of Education and Science (2021), which collects individual data on individual schools. Detailed population data, presenting the population of all localities in Poland, are also available from the Local Data Bank of Statistics Poland (data from the national censuses that take place approximately every ten years). Combining both sets of information – namely assigning the population of localities to a set of schools and assigning information about schools to a set of localities – was a considerable challenge. Although such procedures were mainly performed in an automated manner, using the unique statistical code of the location appearing in both data sets, due to various inaccuracies and missing data, it was still necessary to repeatedly verify situations in which unspecified data had not been successfully connected, and this resulted in the manual completion of both sets. During the collection of this data, concerning over 13,200 primary schools and over 42,400 statistical localities, this situation occurred in more than 160 cases. The sample testing to verify the final files involved verifying the data in the tables with the actual status for randomly selected row intervals.

The article uses the population of all localities in Poland (without division into towns and villages) as of 2021 (data from the National Census) and data presenting the essential characteristics of all primary schools in Poland (locality, number of students, number of school classes) as of the beginning of the 2021/2022 school year (30 September 2021). In order to use combined data from both sources, several research methods were used, ranging from simple intensity and structure indicators to correlation diagrams for cumulative series and methods of non-hierarchical grouping of variables. The analysis concerns standard primary schools for children and youth. Special schools, schools in correctional facilities and educational centres for youth, and those from institutions that have zero students in the records, have been omitted.

Findings

In Poland, in 2021, there were 13,153 primary schools in 8,856 localities. At 42,400 of the so-called statistical localities in Poland, there was, on average, one primary school for every 4.8 localities. The so-called primary services schools are located in all medium and larger towns – they are present in all towns with over 10,000 inhabitants and, with one exception, in all towns with a population of 5,001–10,000 (see table 1). Below this size range, the share of localities with schools declines. Initially, it is small – in 2021, primary schools were located in 84% of localities with a population of 1,001–2,000. Below this size threshold, there is a significant drop in the number of schools – they occur in 59% of localities with 501–1,000 inhabitants and in only 18% of localities with 201–500 inhabitants. Based on these values, if there is a threshold or a range in the size of a locality that can be defined as critical for the presence of schools, it should be between 201 and 1,000 inhabitants. Such a threshold or range can be treated as an approximate locality size 'capable' of supporting a school. It is worth emphasizing that this is not about theoretical value, which is a derivative of its demographic potential (in 2021, primary school students constituted 8.9% of the population, so, on average, a locality inhabited by 1,000 people 'supplied' 89 students), but by a specific empirical value, indicating what population of the locality, given all local settlement conditions and current organizational and financial conditions, is, on average,

sufficient for the functioning of a primary school (regardless of the scope of its catchment area – namely its surface area and how many localities it covers).

More detailed data – namely, showing the share of localities with schools in ten size subcategories of localities with up to 1,000 inhabitants – allow only an approximate indication of the desired size (see Fig. 1). It can be noticed that the decrease in the share of localities with schools is relatively small up to the number of inhabitants amounting to 701–799. In this group of localities, 2/3 have a primary school in their area. In the group of localities inhabited by 601–700 people, this share was 60%, while in the groups 501–600, 401–500, and 301–400, it was only 45%, 34% and 20%, respectively. It demonstrates that at the beginning of the third decade of the 21st century, schools were a common element in the space of localities with over 700 inhabitants and a rare element in the space of localities with fewer than 400 inhabitants.

The data presented in table 2 indicate that the size of the locality has almost no impact on the average values of the school size, the number of classes and their size in localities with over 5,000 inhabitants. The values of these three characteristics differ slightly between localities with a population of 5,001–10,000 and the remaining categories covering larger towns. Additionally, institutions in larger towns and cities are more diverse in size than in smaller ones, which can be explained, on the one hand, by differences in local educational policies in towns or cities of a given size class, and, on the other, by the higher share of non-public schools in these classes, which are on average smaller than public schools (Bajerski 2021).

The initial identification of an approximate threshold of around 5,000 inhabitants in a locality, as a value above which the number of inhabitants in the locality does not translate into the average size of schools, is worth further verification.

The first verification method is to analyse the scatter diagram (Fig. 2), where all schools in localities with less than 15,000 inhabitants are marked. Already this diagram indicates a near-linear relationship between the size of the locality and the size of the school in the range of 0–4,000 inhabitants.

The second method is to analyse the value of Pearson's linear correlation coefficients for successive cumulative ranges of settlement size (increasing every 100 inhabitants of a settlement), starting from 0–100 inhabitants, through 0–200 inhabitants, 0–300 inhabitants, and all the way to 0–15,000 inhabitants. The results of this analysis, presented in the form of a chart, indicate that the maximum value of the coefficient in question is already reached for the interval of 0–4,100 inhabitants (0.62), after which (in the interval of 4,100–10,100), it retains values of at least 0.6 (Fig. 3). On this basis, 4,100 inhabitants can be taken as the critical size of the locality, up to which there is a linear relationship between the number of inhabitants and the size of the school (the number of its pupils). Although it is difficult to speak here of school size being determined by the size of the locality, as this explains statistically just over 38% of the variation in school size, this value is high enough to consider the size of the locality as a significant factor shaping the size of schools in villages and small towns in Poland.

The locality size threshold of 4,100 inhabitants is interesting for at least one more reason – a locality of that size should have, on average, 364 compulsory primary school pupils (in 2021, on average, there were 89 primary school pupils per 1,000 inhabitants in Poland). Disregarding various local demographic and population factors, this enables an eight-grade primary school with two relatively large school divisions per individual year group. Bearing in mind that, in smaller localities, surrounding towns and villages are often also included in school catchment areas, the average total number of pupils in a school catchment

Table 1. Localities with schools by size classes in 2021

Locality size class (number of inhabitants)	Localities		Share (%) of localities with school
	Total number	With a school	
500,001 and more	5	5	100.0
200,001–500,000	8	8	100.0
100,001–200,000	23	23	100.0
50,001–100,000	47	47	100.0
20,001–50,000	125	125	100.0
10,001–20,000	184	184	100.0
5,001–10,000	245	244	99.6
2,001–5,000	1,049	998	95.1
1,001–2,000	2,147	1,801	83.9
501–1,000	4,583	2,720	59.3
201–500	12,480	2,204	17.7
101–200	10,901	417	3.8
100 and fewer	10,633	81	0.8

Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data.

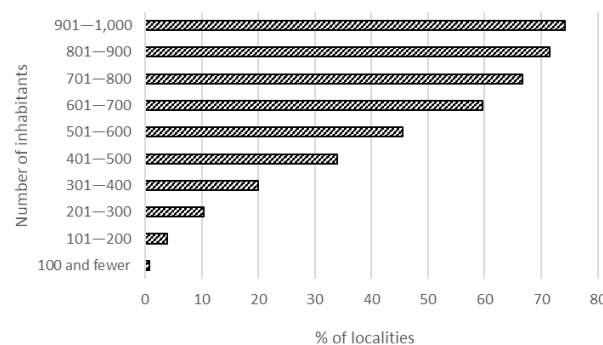


Figure 1. Presence of a school among localities with fewer than 1,000 inhabitants in 2021.

Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data.

area would probably be comparable to the school catchment areas in medium-sized and large towns.

Another way to capture the relationship between the size of a locality and the size of a school is to analyse the size structures of schools in different locality size classes – in particular, to attempt to distinguish the groups of locality size classes with similar school size structures. The similarity was determined using hierarchical clustering (Ward's method), using the square of the Euclidean distance to calculate the taxonomic distances between the locality size classes.

The results of hierarchical clustering made it possible to separate three groups of localities with similar school size structures (Fig. 4). These are as follows:

Table 2. Basic statistics for schools by size class of locality in 2021

Locality size class	Average school size (number of pupils)	Average number of school divisions	Average size of school division (number of pupils)
500,001 and more	398.5	20.0	19.9
200,001–500,000	401.9	20.4	19.7
100,001–200,000	382.6	19.0	20.1
50,001–100,000	405.5	19.9	20.4
20,001–50,000	403.7	19.8	20.4
10,001–20,000	442.2	21.4	20.7
5,001–10,000	420.1	20.6	20.4
2,001–5,000	321.4	16.8	19.2
1,001–2,000	207.7	12.0	17.2
501–1,000	134.3	9.5	14.1
201–500	103.3	8.7	11.9
101–200	90.8	8.5	10.7
100 and fewer	75.3	8.2	9.2

Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data

Group A (localities with fewer than 1,000 inhabitants) – characterized by a school size with a predominance of small schools (up to 70 pupils) and smaller medium-sized schools (71–150 pupils), whose total share in localities with up to 500 inhabitants exceeds 83%, and is 68% in localities with 501–1000 inhabitants. The share of small schools, on the other hand, ranges from 54% for localities with fewer than 100 inhabitants to 19% for the largest localities in this group.

Group B (localities with 1,001–2,000 inhabitants) – the size structure can be described as 'transitional', falling between the structures for smaller and larger localities. First, they are characterized by – as is typical for group C – a low share of small schools (less than 3%). Second, they are characterized by – as is typical for group A – a relatively low share of large schools (less than 18%). The size structure of schools is dominated by medium-sized schools, whose share counts for 80%.

Group C (localities with more than 2,000 inhabitants) – characterized by the highest proportion of large schools (301 pupils and above), which is over 50%. Together with the larger medium-sized schools (151–300 pupils), the respective shares for each category included in Group C are over 80%.

Discussion

The main aim of this article was to determine the relationship between the number of inhabitants in localities in Poland and the presence of primary schools and their characteristics. Undertaking this task stemmed from a deep conviction that despite the considerable development of geographic–educational research in recent years, we still need to learn more about the general relationship between settlement networks and school networks. This knowledge is needed not only for purely research reasons

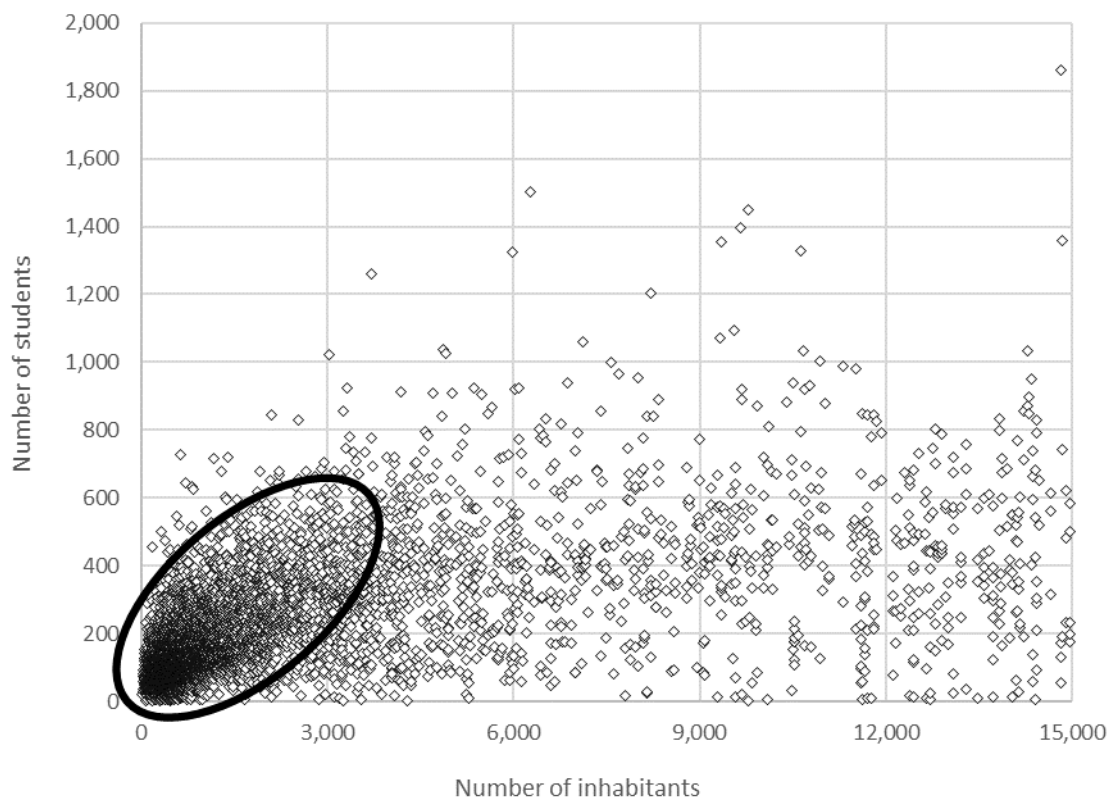


Figure 2. Distribution of the average size of schools according to the population of towns with up to 15,000 inhabitants. Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data.

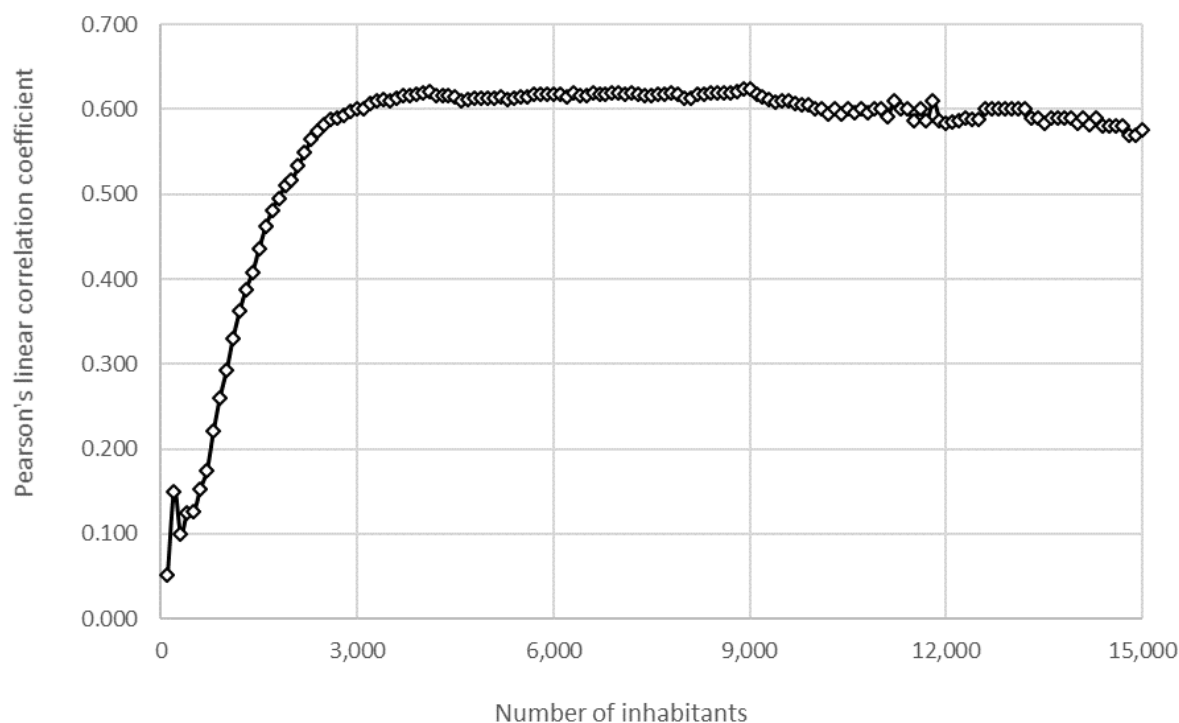


Figure 3. Value of Pearson's linear correlation coefficient between township size and school size for successive cumulative ranges of locality size, i.e. 0–100 inhabitants, 0–200 inhabitants, ..., 0–15,000 inhabitants

Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data

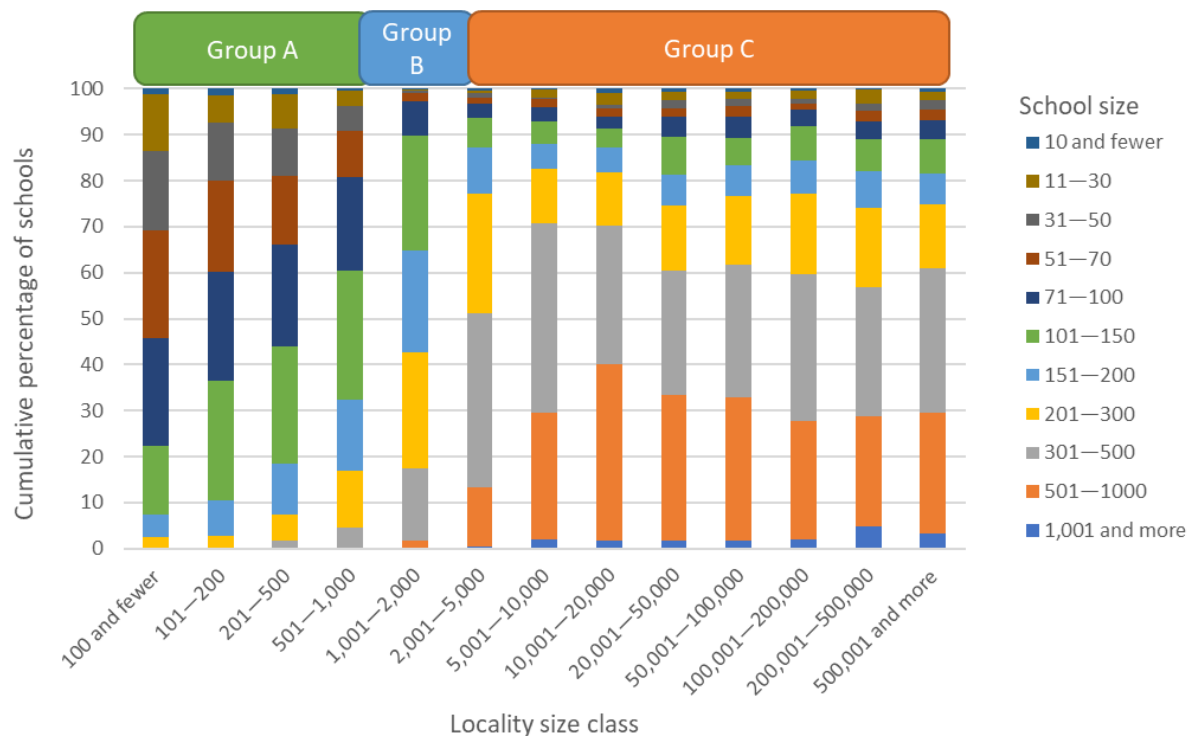


Figure 4. Groups of school size structures in different locality size classes.

Source: own elaboration based on Statistics Poland (2022) and Ministry of Education and Science (2021) data.

but also for practical reasons – it should provide an important context for shaping education policies and spatially fair funding mechanisms for education.

The research findings presented in this article revealed several regularities. The most elementary of these is the relationship between the size of the settlement (number of inhabitants) and the presence of primary schools. Drawing on nationwide data encompassing more than 42,400 localities and 13,100 schools in Poland, the analysis demonstrated that primary schools are commonly found in localities with more than 700 inhabitants. At the same time, they are rare in localities with fewer than 400 inhabitants.

A comparison between the findings presented here for Poland and those of international studies on school networks may lead to a number of interesting observations. For instance, Singh et al. (2008) found that, in India, based on the results of the 2001 census, primary schools were present in more than two-thirds of villages with fewer than 1,000 inhabitants, in nearly 92% of villages with 1,000–2,500 inhabitants and in almost 94% of larger villages. While these figures are not directly comparable to those in the present study (villages versus all types of localities, including towns), as well as presenting temporal differences (2001 versus 2021), they nonetheless suggest several important conclusions.

First, the disparity in school provision between the countries with different levels of economic development may be small. Second, provision may be more widespread in less developed countries. Third, these differences may reflect differing stages in the evolution of the school networks. In Western countries such as Poland, there has been a multi-year and demographically driven decline in the number of schools in rural areas (largely due to long-term depopulation processes – e.g. Kučerová et al. 2020b). In contrast, in India, under conditions of steady population growth, the school network still seems to be on the rise.

This broader context is particularly relevant when considering the population threshold of 401–700 inhabitants as crucial for the incidence of schools in contemporary Poland. Continued depopulation, especially in peripheral rural areas (see Stanny 2011), may lead to an 'upward' shift of the indicated threshold in subsequent years.

The paper also examined a different type of relationship – namely, that between the size of the school and the size of the locality. Specifically, it sought to identify the size range of the localities in which this relationship is strongest. The results indicate that the strongest relationship occurs in the 0–4,100 inhabitant range, where the size of the locality can explain more than one-third of the variation in school size. These values indicate, on the one hand, the very local determinants of school size (Domalewski 2010), which should be understood as a complex combination of circumstances that led to the organization of such a school network (e.g. settlement, natural world, demographic, historical conditions, local educational policy; Piwowarski 1992, Bajerski 2021). On the other hand, the statistical relationship observed indicates that the locality size is a significant factor shaping the size of schools in Poland in small localities. Moreover, the identification of a critical threshold of approximately 4,100 inhabitants may have practical policy implications – it could be used, for example, when modifying the educational subsidy algorithm. In Poland, the current formula includes a rural weighting, which allocates additional funds to schools located in rural areas (irrespective of the number of inhabitants) and to towns with fewer than 5,000 inhabitants. This approach has long been criticized as not sufficiently adapted to the actual costs faced by municipalities running schools in different areas and localities of different sizes (e.g. Herczyński & Siwińska-Gorzelak 2016).

The above finding, unsurprisingly, is related to the size structure of schools in different locality size classes. The study identified three distinct groups of localities in Poland, each characterized by a specific school size structure. The first group comprises the smallest localities with up to 1,000 inhabitants, where small schools and smaller medium-sized schools (up to 150 students) are predominant. The second group includes localities with more than 2,000 inhabitants, where large schools and larger medium-sized schools (with more than 150 students) are more common. The third – a transitional group – consists of localities with a population of 1,000–2,000, exhibiting a mixed structure.

The most important finding is that the size structures of schools in localities with 2,000–5,000 inhabitants are more similar to those of the largest cities than to those of smaller settlements. This suggests that, in localities with a population of 3,001–4,000, there are schools with the quantitative characteristics of metropolitan schools, which is associated with high financial and operational efficiency.

The analyses conducted and the conclusions drawn are subject to certain limitations.

First, the occurrence of schools and their characteristics were analysed solely in relation to the overall population size of each locality. This approach made it possible to employ locality size classes as a framework for the presentation of research results. Demographic structures – for example, the share of school-age children and youth – were deliberately not analysed; this would be more appropriate if the aim of the research was strictly to estimate the degree of actual fulfilment of educational needs.

Second, although the study covered individual localities and schools, the focus remained on macro-level statistical relationships, disregarding the local and regional conditions influencing school location and organization. Previous studies have demonstrated significant differentiation of school networks in Poland, both from a centre-periphery perspective and a regional perspective (Piwowarski 1992; Domalewski 2010; Bajerski 2014, 2021). These findings suggest that the relationship between locality size and the presence of schools and their size may differ considerably depending on regional settlement patterns. For this reason, it would be valuable to validate the findings at various spatial scales, paying particular attention to the differing dynamics of fast-growing urban regions and depopulating rural areas. The results of such analyses could provide a valuable contribution to ongoing debates on the potential introduction of territorially sensitive funding algorithms for primary education – namely mechanisms that reflect regional differences in settlement structure in order to ensure a more spatially equitable allocation of public education resources.

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