

Article

Is There Any Relation between the Architectural Characteristics of Kindergartens and the Spread of the New Coronavirus in Them?—A Case Study of Slovenia

Vesna Lovec , Miroslav Premrov and Vesna Žegarac Leskovar * 

Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Smetanova ulica 17, 2000 Maribor, Slovenia; vesna.lovec@um.si (V.L.); miroslav.premrov@um.si (M.P.)

* Correspondence: vesna.zegarac@um.si; Tel.: +386-40-616-090

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Abstract: The COVID-19 era is bringing changes to different parts of everyday life, redefining what people used to consider normal. As the world deals with this highly contagious disease, the issue of the built environment, buildings, their architecture and possible relations among their characteristics and the spread of the virus remains unclear. Preschool and school education is an essential part of society. However, with the spread of COVID-19, kindergartens and schools keep on partly or fully closing and reopening, trying to provide a safe and healthy environment for children. Instructions and recommendations from different experts and organisations worldwide were announced in terms of how to adjust the functioning of kindergartens in conditions of the uncontrolled spread of COVID-19. The measures include organisational and hygiene measures. Organisational measures are closely related to the architectural design of a building. At this point, the main question of this research was raised: is there any relation between the architectural characteristics of kindergartens and the spread of the new coronavirus in them? The research examined the architectural characteristics of kindergartens in Slovenia with reported COVID-19 cases among staff or children.

Keywords: COVID-19; kindergartens; building; architecture

1. Introduction

In December 2019, a new highly infectious virus, i.e., severe acute respiratory syndrome coronavirus (SARS-CoV-2), was discovered in China. Until late March 2020, it was clear that the world is undergoing a global COVID-19 pandemic caused by SARS-CoV-2. The World Health Organization (WHO) has officially classified the COVID-19 outbreak as a pandemic [1]. With the COVID-19 outbreak, humanity has been facing a global crisis, which has an impact on every aspect of society, economy, health, culture, etc. The COVID-19 crisis also has the environmental impact in terms of air quality and pollution [2–4], energy consumption [5], air and water quality [6], etc. And most importantly for this study, it has impact on the built environment and preschool education, to which special attention will be paid in this paper.

Kindergartens and schools across the world closed in March 2020 after the pandemic outbreak. Educational facilities were closed for more than two months. As the spread of the virus slowed down, most European countries reopened kindergartens and schools in May 2020. At the beginning of the new 2020/2021 school year, most kindergartens and schools around the world reopened in full range, yet many facts remained unknown about the role of children in the virus transmission. What becomes clear is the fact that society has to learn to live with the virus and has to find a way to keep educational facilities operating as normally as possible.

Kindergartens are an essential part of society by taking care of children and providing a place for social experience and acquiring knowledge. They also provide nutrition, health and hygiene services, and mental health and psychosocial support. Apart from their critical contribution to socialisation, child development, and early education, they are an essential service for employed parents with an important contribution to children's health, safety and well-being. Therefore, they are a crucial part of sustainable society. Nevertheless, kindergartens hosting numerous children each day can be classified as high-density buildings. The risk of spreading the virus in the building is considered to be high. On the other hand, closing the kindergartens to prevent the spread of the virus poses a risk to children's education, protection and well-being. To this end, it is extremely important to find the optimal solution for kindergartens to remain open in the COVID-19 era.

1.1. Literature Review

1.1.1. Children and COVID-19

Kindergartens and schools across the world closed in March 2020 with the outbreak of COVID-19. All educational facilities were closed for more than two months. As the epidemic faded, most European countries gradually reopened kindergartens and schools in May 2020. At the beginning of the new 2020/2021 school year, most kindergartens and schools around the world reopened in full range. Now, at the end of October 2020, Europe is facing another growth in the number of positive cases and kindergartens are fully or partially closing. In the meantime, numerous scientific researches related to different aspects of COVID-19 are ongoing worldwide. Research has been targeting different aspects of COVID-19, medical and clinical studies about the disease and its transmission, environmental studies, social studies, etc. Regarding the literature review, important for this study is research which can help to answer the question whether there is any relation between the kindergarten building architecture and the transmission of the virus within the building. Therefore, the literature review has two parts: (1) children and COVID-19, and (2) the influence of the pandemic on the built environment.

So far, the questions of how likely children are to get the virus and what role children play in the spread of the new virus have caused a lot of controversy. These are vital questions when it comes to deciding whether kindergartens should remain open in the COVID-19 era. However, researchers have been divided on whether children are less likely to get infected and to spread the virus than adults.

The fact that is clear so far is that the disease is generally far less severe for children than it can be for older adults. Children often have milder disease and deaths among children are extremely rare [7]. The fact is also that children (under 18 years of age) constitute a small fraction of confirmed COVID-19 cases, i.e., less than 5% of cases reported in the EU/EEA and the UK are among children according to the European Centre for Disease Prevention and Control (ECDC) [8]. Studies from China support the suggestion that children are less susceptible to infection [9]. According to the WHO, data suggest that children under the age of 18 represent about 8.5% of the reported cases with relatively few deaths compared to other age groups and usually mild disease [10].

Children can catch the virus and either show symptoms or not, which hinders analyses and conclusions on the transmission of the virus among children or from children to adults. The findings of the ECDC indicate that, when symptomatic, children shed virus in similar quantities to adults and can infect others in a similar way to adults. It is unknown how infectious asymptomatic children are [8]. Also, there are no precise data on how many of asymptomatic children we should expect to be in groups, i.e., approximately between four and 28% of asymptomatic paediatric cases among cases tested based on symptoms, signs or contact tracing [7,11]. The first large-scale study of the COVID-19 transmission in US child care programmes found no evidence of childcare being a significant contributor to the COVID-19 transmission to adults [12]. Very few significant outbreaks of COVID-19 in schools have been documented so far. They do occur but may be difficult to detect due to the relative lack of symptoms in children. After reopening, only few and mostly small COVID-19 school outbreaks were reported in Germany [13].

Outbreaks in kindergartens were not the topic of available research. However, data change daily and the question remains: should we expect significant outbreaks in school and kindergartens with the number of positive COVID-19 cases increasing in the late autumn and the winter of 2020?

The role of children in the spread of the virus remains unclear. New findings emerge daily about transmission routes and the clinical profile of SARS-CoV-2, including the substantially underestimated infection rate in children [14]. On the other hand, the paper published in *Acta Paediatrica* summarises the findings of a systematic literature review of the current knowledge of COVID-19 transmission in children, suggesting that opening up schools and kindergartens is unlikely to impact COVID-19 mortality rates in older people. The systematic review included 47 publications and was conducted by researchers at Karolinska Institute in Sweden [7]. The study of Centers for Disease Control and Prevention (CDC) adds to the growing evidence that children can spread the coronavirus. Very young children can catch COVID-19 and transmit the virus to adults, even if they never show symptoms, according to a study published by the CDC [15]. Twelve children were infected by someone else at a childcare facility and most had mild to no symptoms. Through detailed contact tracing, investigators were able to determine that those children afterwards transmitted the virus to at least one in four persons they were in close contact with outside of the childcare facility. Those contacts usually included mothers and siblings. Researchers found the likely rate of transmission between children and their close contacts outside of childcare centres was 26% [15]. There are also studies proving exposure in childcare was not associated with an elevated risk of transmitting COVID-19 from children to adults, provided the childcare programs took multiple safety measures—including disinfecting, handwashing, symptom screening, social distancing, mask-wearing, and limiting group size—and were located in communities where the spread of COVID-19 was contained [12].

Overall, it can be concluded that there is evidence that children are less likely to catch the virus and that the disease is generally far less severe for children. However, the facts about the role of children (both symptomatic and asymptomatic) in the spread of the virus remain unclear and controversial.

The general attitude of the WHO suggests that the role of children in the spread of the virus is not yet fully understood. Further studies are underway on the role of children in the spread in and outside of educational settings. With current findings and numerous ongoing researches regarding the COVID-19 issues, the WHO is working to develop protocols that countries can use to study COVID-19 transmission in educational institutions [16].

1.1.2. Influence of the Pandemic on the Built Environment—Architecture after the Pandemic

In creating the built environment, architects and building engineers have been striving to create a safe and healthy indoor environment, which is extremely important in public buildings, such as kindergartens. Complex codes, regulations, and guidelines were developed to achieve goals, such as structural and fire safety of the buildings, energy efficiency, and indoor environmental quality, and to anticipate extreme scenarios, such as strong earthquakes or 100-year floods. Yet, the new physical distancing recommendations indicated due to the COVID-19 outbreak have not been predicted by contemporary architecture but will certainly impact architectural practice in future. Future architectural paradigms and the design of houses, offices, public buildings, and public spaces in general are facing the challenge of the COVID-19 era.

The COVID-19 pandemic and lockdown measures have revealed deficiencies in existing residential buildings in terms of health and safety risks, the excess consumption of environmental resources, and the lack of personal comfort [17]. After the COVID-19 era, more people are expected to work from home, and as a result, the future of home design might change [18]. Regarding layout and design solutions, post-pandemic housing might introduce more partitions between departments and open-plan spaces might come to an end [19]. Flexible and adaptable spaces for all users can make housing more sustainable, and adaptable to changing needs and lifestyles [20]. The reflections on housing design, as well as on the design of the built environment in general, in terms of indoor environment quality might be expected based on the latest studies suggesting that increasing air flow

through natural and mechanical ventilation within buildings may help dilute and remove the virus, whereas higher relative humidity can be detrimental to viruses [1].

Also, office spaces will undergo certain changes after the global pandemic and most European countries are already facing the so-called second wave of the virus. Therefore, office spaces might have to provide more space and fewer seating options [21]. The fact is that the architecture of office spaces will have to be seriously reconsidered to satisfy the physical distancing requirements and take into account the fact that remote work is the new norm.

With a high concentration of the population and economic activities, cities are hotspots of COVID-19 infections. Numerous studies have been researching strategies for post-epidemic cities [22]. Other studies point out that the critical role of urban parks in improving the overall health of the population is further emphasized during the pandemic period [23]. Some of the studies point out that urban planning could even be an essential tool for the containment of the virus [24]. The pandemic has transformed our perception of the built environment because of our fear of infection. Consequently, architecture and urbanism will not be the same after the COVID-19 pandemic, although it will take time to develop an antiviral-enabled paradigm to reduce potential risks in the built environment.

The architecture of kindergartens in relation to COVID-19 has not been the topic of available research so far. All further research should help to answer the question of what would it take to redesign institutional and public buildings so they could help “flatten the curve” instead of simply evacuating occupants? As for the architecture of educational buildings, the question is how to adjust a building to be safe, provide a healthy environment for children and staff, and to help to prevent the spread of the virus. The question of adjusting a building targets both sanitary and hygiene and organisational adjustments, which are closely connected to the architecture of kindergartens. Architecture as well as occupant’s behaviour and lifestyle patterns need to adapt and evolve in ways that help people to manage the ongoing pandemic and also potential future ones. Therefore, the aim of this research is to clarify the impact of architecture on the spread of the virus during the ongoing COVID-19 era and also potential future ones.

1.2. Main Objectives and Structure

The specifics of the current study in regard to the literature review are difficult to define due to daily changes in available scientific research and other available information on COVID-19. Most of the ongoing or conducted research targeting the role of children in the spread of the virus are epidemiological. They focus on tracing the COVID-19 cases and the transmission of the virus, and provide contradictory arguments of how likely the virus is to spread within educational facilities. Some of the available research focus on the transmission of the virus among children attending schools, while very few of them focus on kindergartens and childcare centres. Yet, no available research involves the architecture of buildings in relation to the virus transmission. Therefore, the analysis of the possible relation of the kindergarten architecture to the spread of COVID-19 is a valuable scientific contribution of this study to the ongoing dilemma whether kindergartens should remain open or closed to help contain the virus. This research contributes to a very complex topic that must be constantly updated with available data that change daily.

As the world is undergoing global changes when the number of COVID-19 cases is increasing in most European countries, schools and kindergartens should find the way to adjust to the new reality. New measures target both organisational and hygiene measures. Organisational measures are closely related to the architectural characteristics of a building. At this point, the main question of this research was raised: is there any relation between the architectural characteristics of kindergartens and the spreading of the new coronavirus in them? Therefore, the objective of the current paper is to analyse the possible influence of the building architectural characteristic on the spread of the virus among children and between the children and staff in kindergartens. Finally, the results and conclusions of this study should be potentially used in future analyses and research of the possible adjustment of

existing kindergarten facilities to the new circumstances. Nevertheless, they can contribute to the ongoing epidemiological research aiming to explain how the virus spreads among children and adults.

In this research, the selected kindergarten buildings in Slovenia with COVID-19 cases were analysed to answer the question whether there is any relation between the building architectural characteristics and the spread of the virus in kindergartens. The methodology of the study follows three basic steps: (1) collecting data on COVID-19 cases in Slovenian kindergartens, detecting infections in staff and children; (2) the analysis of the architectural characteristics of kindergartens with positive cases; and (3) the analysis of data and the determination of potential relations between architectural characteristics and the potential of the virus to spread.

The content of the current paper is divided into five sections. In Section 1, the problem background and the objectives of the research are presented in addition to the review of the relevant literature. The review of public health measures and the COVID-19 guidelines for kindergartens is presented in Section 2, while in Section 3, the state of the existing national kindergarten building stock is briefly described. The case study of the reported COVID-19 cases in Slovenian kindergartens is presented in Section 4. The final conclusions are given in Section 5.

2. Public Health Measures for Kindergartens Associated with COVID-19

After a two-month lockdown, kindergartens gradually reopened in May 2020. In September 2020, kindergartens fully reopened in most countries worldwide according to the public health measures for kindergartens associated with COVID-19 based on the instructions of the WHO, and local guidelines by governments and healthcare institutions. By the end of October, kindergartens and schools began closing again in most European countries due to the increasing number of COVID-19 cases. On 19 October 2020, an epidemic was declared again in the Republic of Slovenia. Schools and kindergartens gradually closed again with no clear answer to the question how the virus spreads in schools and kindergartens.

At the beginning of the COVID-19 pandemic, countries announced public health measures and recommendations for kindergartens and schools to prevent the spread of the virus, which largely included instructions regarding the sanitary and hygiene regimes in buildings and instructions on maintaining physical distance (defined with organisational measures). In most European countries, the prescribed measures are based on the WHO recommendations.

The National Institute of Public Health of the Republic of Slovenia (NIJZ) has determined numerous measures to contain the spread of the virus in the Hygiene-Related Recommendations for Kindergartens to Prevent the Spread of SARS-CoV-2, which apply to the period when individual, or clusters of, cases appear in the country [25]. Recommendations can be divided into two groups of basic measures:

- hygiene and sanitary measures: room hygiene, hand hygiene and cough etiquette, disinfection, ventilation, mask-wearing, only healthy persons can enter the building;
- organisational measures aiming to reduce contact between children and staff:
 - forming smaller groups of children in separate rooms (groups should be permanent);
 - avoiding crowding in changing and common rooms;
 - groups should be in as little contact with each other as possible;
 - classrooms should be separated from rooms of other groups with a door;
 - as much outdoor activities should be planned as possible.

The goal of hygiene and sanitary measures is to maintain a high level of hygiene to prevent the spread of the virus within the building. Most measures may be applied to buildings and do not depend on their architectural characteristics. On the other hand, the goal of organisational measures is to reduce contact and maintain physical distance between children and staff. They are closely connected with the architectural characteristics of a building. Since kindergartens host children whose ability

to understand the situation and behave appropriately is limited, the implementation of measures is difficult or impossible. For this reason, the said organisational measures and the adjustment of the functional design of a building are extremely important for reducing contact between and among children and staff. All of the analysed kindergartens received the same instructions and followed the same hygiene and sanitary and organisational measures.

In existing kindergartens, organisational measures closely related to the floor plan and the way the building functions had to be implemented. Adjusting existing buildings to the recommendations is a great challenge, bringing thoughts about future kindergarten architecture to a new level with the question of what kindergartens should look like. In the context of these questions, this research investigates the possible connection of the architecture of kindergarten buildings and the spread of the virus among kindergarten staff and children.

3. State of the Existing Building Stock of Kindergartens in Slovenia

Kindergartens and schools constitute a large share of the public building stock in Slovenia. According to the data of the Ministry of Education, Science and Sport, there is a total of 1177 public and private kindergartens with all their units in Slovenia [26]. In the 2018/2019 school year, 87,147 children were involved in the preschool education programs in Slovenia [27]. In addition, there are many kindergarten teachers, expert workers and other workers who spend most of their days in kindergartens throughout Slovenia.

Kindergartens in Slovenia were built in various periods, and are products of various social systems, norms and construction trends. The average age of kindergartens in Slovenia is 45. The period of the most intensive construction was between 1970 and 1980 when the construction of kindergartens kept up with intensive housing construction and kindergartens were built specially for large neighbourhoods of blocks of flats. The architectural and structural characteristics followed the construction trends and are very diverse, from massive concrete to light prefabricated structure systems. Buildings also differ in size, from units with two groups to units with 16 groups in the sample of this research, while certain buildings house up to 26 groups [28].

Most kindergartens in Slovenia were designed in a way that allows each group to have its own classroom. Cloakrooms and toilets are usually shared by two to four groups. Kindergartens with several groups usually have multiple entrances for visitors (children and parents), whereby one entrance is used by three or four groups. Most buildings are ground floor buildings. Many kindergartens in Slovenia and certain parts of former Yugoslavia were designed in this way. Kindergartens are facing an unfamiliar challenge due to the situation in which we found ourselves because of the spread of the new coronavirus. Existing kindergartens must be adjusted to the new coronavirus-related situation. According to the instructions of the WHO and the NIJZ, organisational measures must be used to ensure as little contact between groups as possible, which is very difficult to realise if several groups share toilets and cloakrooms. Only few recently built kindergartens in Slovenia are architecturally designed in a way that every classroom has a separate cloakroom and toilets, which is very convenient for reducing contact among children due to COVID-19.

In addition to kindergartens planned and purpose-built in the second half of the 20th century, it should be mentioned that the existing kindergarten building stock in Slovenia includes approximately 25% of non-purpose-built buildings, i.e., buildings built for another purpose, which are adjusted to preschooling, mainly due to the lack of space Slovenian kindergartens have been facing for decades [29]. Another thing that should be said is that these buildings were not designed to be kindergartens and have numerous limitations, such as common toilets and cloakrooms that cannot be separated for individual groups and one entrance to the building without the option separate entrances for individual groups. In light of COVID-19, the said deficiencies are all the more evident. Most purpose-built buildings with separate entrances and toilets provide numerous options for adjustment, which is not the subject of this research, but it is extremely important and might be the subject of future research.

In the context of the architectural characteristics of kindergartens, the fact that most Slovenian kindergartens were built before 2000, have a closed floor plan and many common rooms due to optimisation (cloakrooms and toilets) should be pointed out. Only in recent decades have kindergartens been planned and built in a way that every group has a separate cloakroom and separate toilets, which is significantly more convenient in the context of the spread of the virus, as groups do not mix. On the other hand, most newer buildings have an open floor plan, which is largely a result of modern architectural trends and pedagogical doctrines and also a disadvantage in the context of the spread of the virus. A closed floor plan can lead to poor ventilation, while a completely open floor plan can cause mass infection due to numerous ongoing contacts among children and staff. Therefore, a semi-open floor plan where a large space can be divided into smaller zones might be the optimal solution for kindergartens in terms of lowering the risk of the virus transmission.

An important factor that can affect the spread of the virus in buildings, particularly in buildings with high density, such as kindergartens, is ventilation. Ventilation in most Slovenian kindergartens is natural and only 12% of kindergartens also have the ventilation system in classrooms [29]. In buildings with natural ventilation, special attention must be paid to the ventilation of classrooms throughout the day. Regarding mechanical ventilation of classrooms, it must be pointed out that, based on previous experience with COVID-19, there is a possibility that the virus spreads through mechanical ventilation systems if they do not function properly or are not properly maintained [30]. Ventilation is crucial to preventing the spread of the virus, but it is not the topic of this research in which it is merely mentioned as a ventilation method in the analysed buildings (all of the analysed kindergartens have solely natural ventilation, i.e., opening windows).

4. Research into the Relationship between the Building Architectural Characteristics and COVID-19 Cases in Kindergartens

4.1. Methodology

The data on recorded COVID-19 cases in Slovenian kindergartens were obtained from the letter of the Ministry of Education, Science and Sport (MIZŠ), Preschool and Basic Education Directorate [31], which contained an extract from the application established by the MIZŠ in September 2020 aimed at collecting data on COVID-19 cases in Slovenian kindergartens. The submitted tables (extract from the application) include data on the absence of staff and children due to confirmed or suspected COVID-19 cases, and data on the rationalisation of work in groups due to confirmed or suspected COVID-19 cases. The data are entered in the application by headteachers.

It may be concluded from this letter that 104 absences of workers due to suspected infections were recorded between 11 September 2020 (the date when the MIZŠ began recording) and 25 September 2020 (the date of the extract from the MIZŠ application). According to the record, 14 COVID-19 cases were confirmed among staff and 67 children were absent due to suspected COVID-19 but without data on actually confirmed cases. The analysed data are from a record covering the two weeks when the average daily number of cases in Slovenia was 108. On 11 September 2020 (the first day of the two weeks when the samples in this research were analysed), the 14-day incidence rate per 100,000 population in Slovenia stood at 34 with the share of positive tests being 3.92%. The trend of the growing number of positive cases continued (also after the two-week sampling period). The record daily number of positive cases (so far) is 2605 recorded in Slovenia on 27 October 2020 with the share of positive tests being almost 35%.

Kindergartens where positive cases were confirmed and individual groups were quarantined under decisions of the National Institute of Public Health (NIJZ) were selected on the basis of the submitted list. The selected kindergartens were contacted by researches taking part in this research and asked to submit additional data on the spread of the infection within the building. Data on the group in which infection was detected, the number of children in the group and the age of the children were recorded. The number of children in each group follows the norms applicable to kindergartens in the Republic of Slovenia. Each group includes two adults, i.e., a teacher and a teacher assistant. For this

study, data on the general and architectural characteristics of the buildings, and on how kindergartens prevent the spread of the disease among children and staff were collected.

Eleven buildings where COVID-19 was confirmed and individual groups were quarantined were analysed in more detail. The range of buildings where COVID-19 was confirmed is very diverse. The data on the buildings were collected through interviews with the management of kindergartens, visits to the buildings and the record of the Surveying and Mapping Authority of the Republic of Slovenia. The general, architectural and structural characteristics of the buildings presented in Table 1 below were recorded.

Table 1. Data on analysed buildings.

No. of Building	No. of Groups	Floors	Year of Construction	Structure [32]	Special Features of the Building
1	6	G	1971	Concrete/reinforced concrete	Two entrances to the building. Groups share cloakrooms and toilets.
2	10	G	1973	Prefabricated	Three entrances to the building. Groups share cloakrooms and toilets.
3	16	G+1	1978	Concrete/reinforced concrete	Three entrances and three staircases. Groups share cloakrooms and toilets. Numerous common rooms.
4	9	G	1981	Concrete/reinforced concrete	Three entrances. Toilets are shared by two groups, common cloakrooms in the hall. Numerous common rooms.
5	A specific case of infection in the management of the kindergarten. The characteristics of the building are not recorded.				
6	3	G	1986	Brick	Entrance for two groups that share toilets and cloakrooms. The third groups is completely separate with a separate entrance and cloakrooms.
7	6	G + 1	2012	Brick	Two entrances to the building. One staircase (two groups on the first floor). Toilets are shared by two groups, common cloakrooms in the hall. Numerous common rooms.
8	4	G	2006	Concrete/reinforced concrete	One entrance for all four groups. Three groups share cloakrooms and toilets.
9	9	G + 1	1900	Brick	One entrance to the building. One staircase. Four groups on the ground floor share cloakrooms in the common hall. Common toilets for three groups.
10	2	G	1907	Brick	One entrance to the building. The two groups share toilets and cloakrooms. Numerous common rooms.
11	6	G	1986	Concrete/reinforced concrete	Two entrances to the building. Each group has its own toilets. Common cloakrooms in the hall.

The analysed sample of buildings with confirmed COVID-19 cases included purpose-built (buildings 1, 2, 3, 4, 5, 7, 8 and 11) and non-purpose-built (buildings 6, 9 and 10) kindergartens that were built between 1907 and 2012. The buildings house between two and 16 groups of children of all ages. All buildings are detached with one floor, i.e., the ground floor, only three of them have multiple floors. Most kindergartens have common cloakrooms and toilets shared by two to four groups. All buildings are detached and located on building plots.

The main technical obstacle in this research which must be mentioned is the availability of data on infections in kindergartens in Slovenia which are not published and whose collection was quite a challenge. The data for the period between 11 September and 25 September 2020 were available to us for this research. During the period when the data were analysed and processed, the Republic of Slovenia declared an epidemic again and kindergartens closed (they only provide emergency childcare for parents who cannot work from home or do not have any other childcare option for their children) due to the increasing number of COVID-19 cases. After the emergency situation was declared again, the access to data is further hindered due to excessive workload in public institutions.

In substantive terms, we should mention the fact that the nature of the spread of the virus among children and its transmission from children to adults is an epidemiological and medical issue and not the subject of this research. The question of how the virus will spread within a building is very complex and, in addition to the epidemiological element, also includes the issues of hygiene and sanitary measures and ventilation, which are extremely important for the spread of the virus but are not the topic of this research in which the ventilation method in the analysed buildings is merely mentioned (all of the analysed kindergartens have solely natural ventilation, i.e., opening windows), and foresees the fact that all buildings follow the prescribed hygiene and sanitary measures. Analysed kindergartens presumably followed the common ventilation pattern of naturally ventilated kindergartens in Slovenia. Ventilation intervals within the 9-h span are three times a day 10 to 30 min (before opening, during outdoor activities and after lunch). During the ventilation periods no occupants are in the classroom, and cross-ventilation is used if possible. That is the common pattern used during the heating season. In periods when outdoor temperatures are higher windows are mostly partly opened all day. Since the study is targeting the period in early September with relatively high daily temperatures it is difficult to comment the ventilation rates due to the fact that probably most of the rooms have partly opened windows during the day. Besides, quality of ventilation in naturally ventilated classrooms are directly depending on the occupants (teachers) and is difficult to estimate. Available research suggests that, besides a ventilation source, also indoor air humidity and light/daylight can affect the composition of indoor microbial communities [33]. However, the ventilating in relation to the spreading of the virus should be treated comprehensively and is recommended to be the target of the future research.

The question of how the virus will spread in kindergartens, particularly among staff, is very complex and is not only the question of the architectural zoning of a building, as kindergartens have restricted the movement of individual groups and supervise the movement of children within their organisational units. However, there is still the issue of staff who are theoretically restricted to individual zones, which is difficult to realise in practice. In this research, we can merely anticipate how staff will move around but cannot know for certain where they move and who they are in contact with within the kindergarten.

4.2. Results

In the two-week sampling period, the total of 22 COVID-19 cases were recorded in the eleven analysed kindergartens in Slovenia, of which four cases were confirmed in children and 18 in teachers. In eight buildings, one group was quarantined in each of them, while in two buildings, several groups were quarantined in each of them. The management of one kindergarten was also quarantined. The data on the number of quarantined groups, the number of infected teachers and children, the age group, and the number of children in a classroom are shown in Table 2.

Table 2. Analysis of recorded infections in kindergartens in Slovenia.

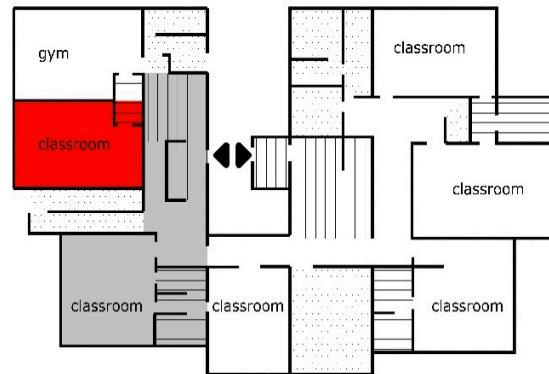
No. of Building	No. of Groups with Infections	No. of Infections—Children	No. of Infections—Teachers	Age of Children (Years)	No. of Children in the Group	Special Infection-Related Particularities. The Way the Building and Groups Function
1	1	/	1	2–3	14	A teacher who worked in two groups was infected. The groups are completely separate with each of them having its own cloakroom and toilets.
2	1	/	1	4–5	21	The group shares toilets and cloakrooms with two other groups.
3	1	/	1	3–6	21	The group shares the cloakroom (in the hall) with three other groups. It shares toilets with one other group.
4	3	/	3	2–3	14	Teachers in three groups were infected; the groups are not connected and the children in these groups did not mix.
		/		4–5	21	
		/		1–2	14	
5	/	/	2	/	/	Two expert workers in the management of the kindergarten were infected. As a result, the management was quarantined.
6	1	/	1	1–3	14	A teacher in one group was infected. The group shares toilets and cloakrooms with one other group.
7	1	/	1	3–4	18	A teacher in one group was infected. The group shares toilets with one other group, while cloakrooms are in the common hall shared by three other groups.
8	1	1	/	4–6	24	The group in which a child was infected shares toilets and cloakrooms with three other groups.

Table 2. Cont.

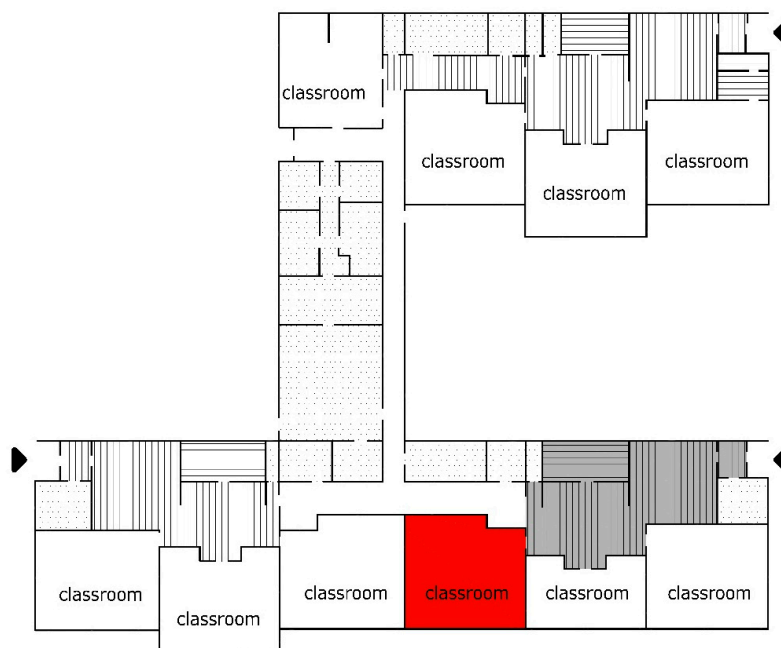
No. of Building	No. of Groups with Infections	No. of Infections—Children	No. of Infections—Teachers	Age of Children (Years)	No. of Children in the Group	Special Infection-Related Particularities. The Way the Building and Groups Function
9	1	1	2	1–2	14	One child in a group was infected first, followed by two expert workers. Children share cloakrooms at the end of the hall with three other groups. They share toilets with two other groups.
10	2	1	3	1–4	17	One child and five teachers in two groups were infected.
		/	2	3–6	21	The groups share cloakrooms and toilets. The teachers share common rooms.
11	1	1	1	1–3	14	One child in a group was infected first, followed by a teacher. The group has its own toilets. It shares cloakrooms in the hall with five other groups.

Presented below are the floor plans of all of the discussed buildings, and the locations of classrooms with confirmed COVID-19 cases and the zone where the children in groups with confirmed cases moved are marked. The graphic presentation does not include the building with a confirmed case in the management, as the management is located in a separate part of the building, which makes it irrelevant for this research (building no. 5). In most cases with confirmed COVID-19 in a classroom, the children in this group shared cloakrooms and/or toilets with children from other groups, which is evident from the graphic presentation (Figure 1). The movement of teachers within buildings can only be anticipated, as other rooms intended for staff only can be used by staff when they are not in their classrooms. In addition, there are many personal contacts among staff, which makes monitoring very difficult.

(Kindergarten no.1) No. of infections: children: 0/teachers: 1



(Kindergarten no.2) No. of infections: children: 0/teachers: 1



(Kindergarten no.3) No. of infections: children: 0/teachers: 1

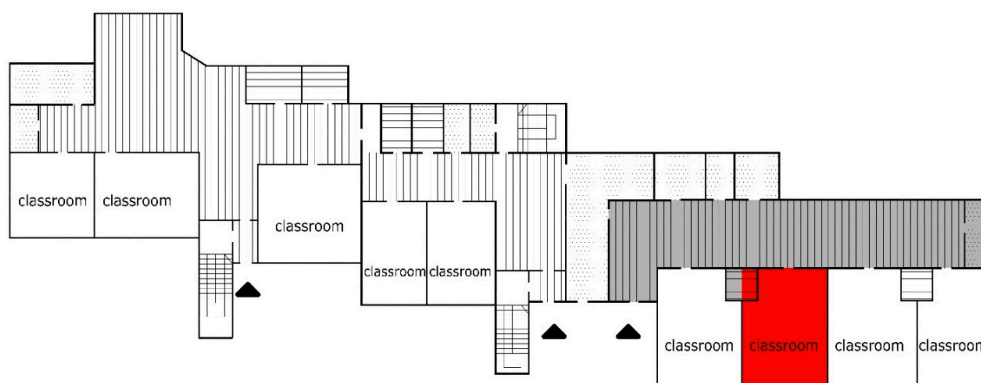
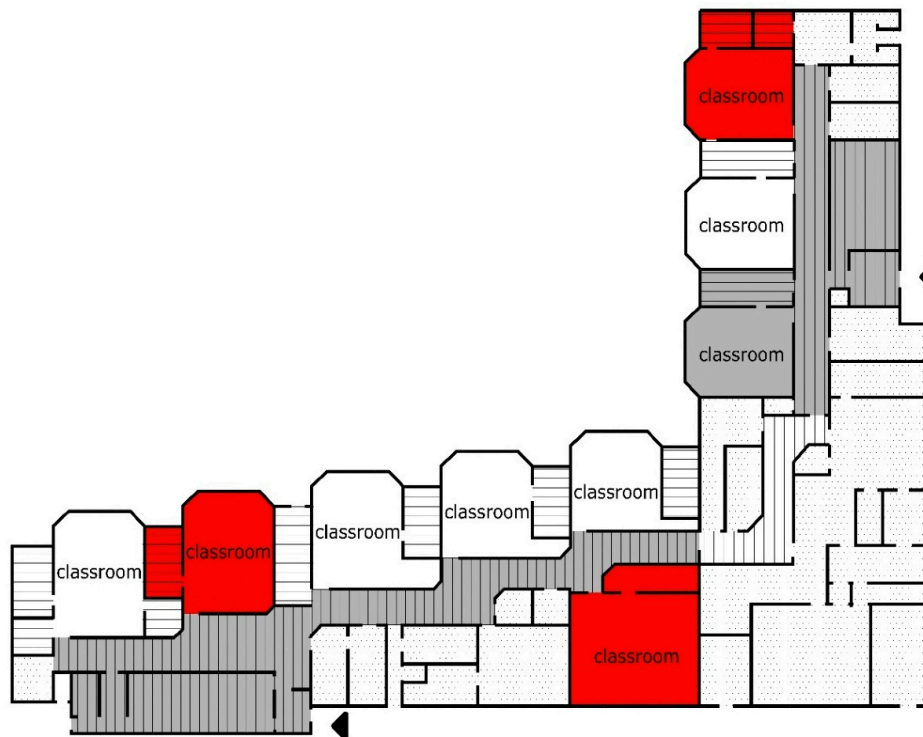
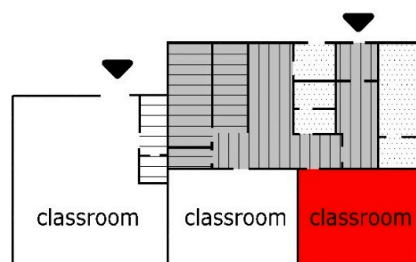


Figure 1. Cont.

(Kindergarten no.4) No. of infections: children: 0/teachers: 3



(Kindergarten no.6) No. of infections: children: 0/teachers: 1



(Kindergarten no.7) No. of infections: children: 0/teachers: 1

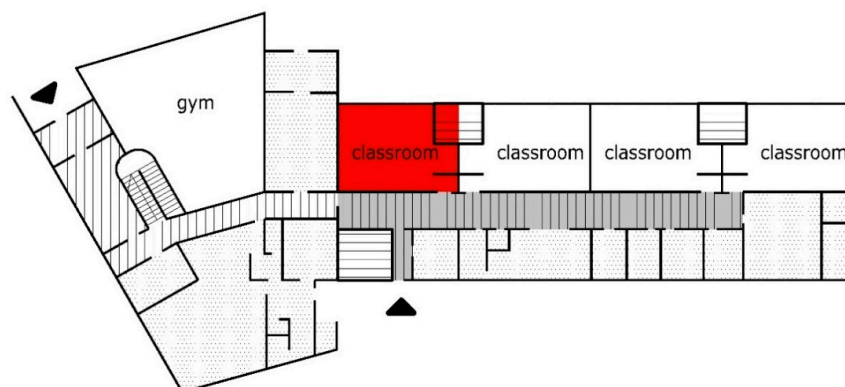
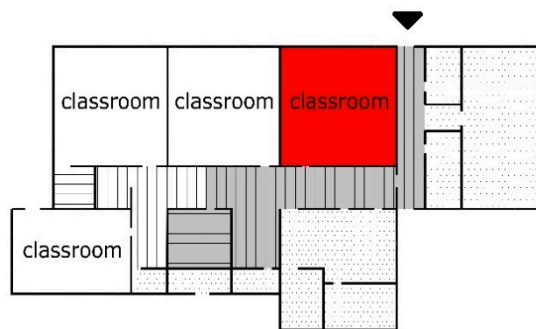
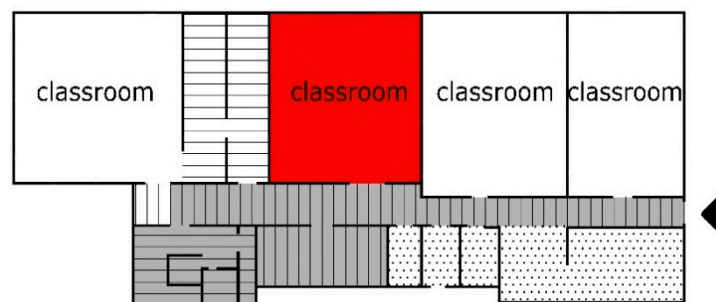


Figure 1. Cont.

(Kindergarten no.8) No. of infections: children: 1/teachers: 0



(Kindergarten no.9) No. of infections: children: 1/teachers: 2



(Kindergarten no.10) No. of infections: children: 1/teachers: 5

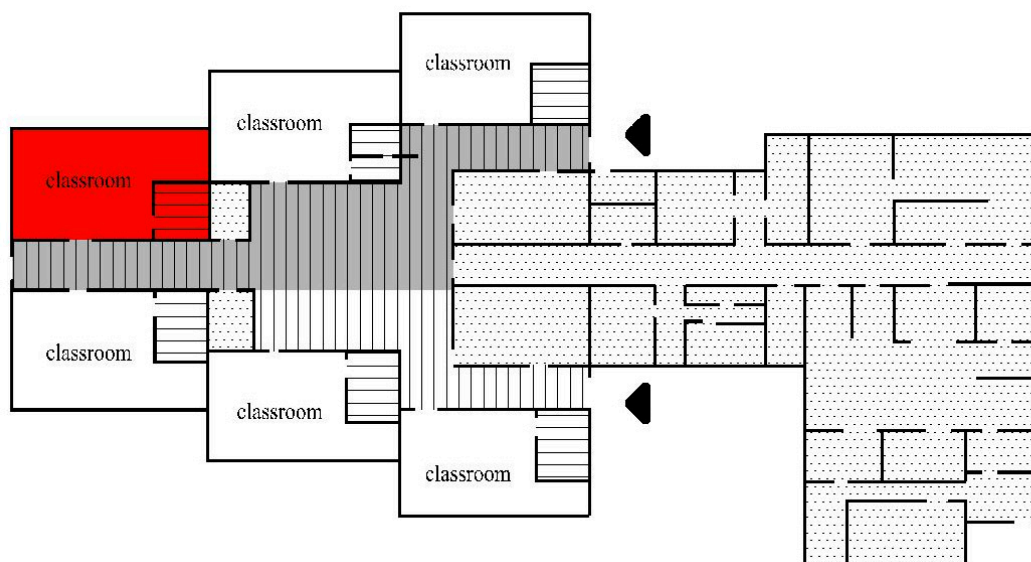


Figure 1. Cont.

(Kindergarten no.11) No. of infections: children: 1/teachers: 1

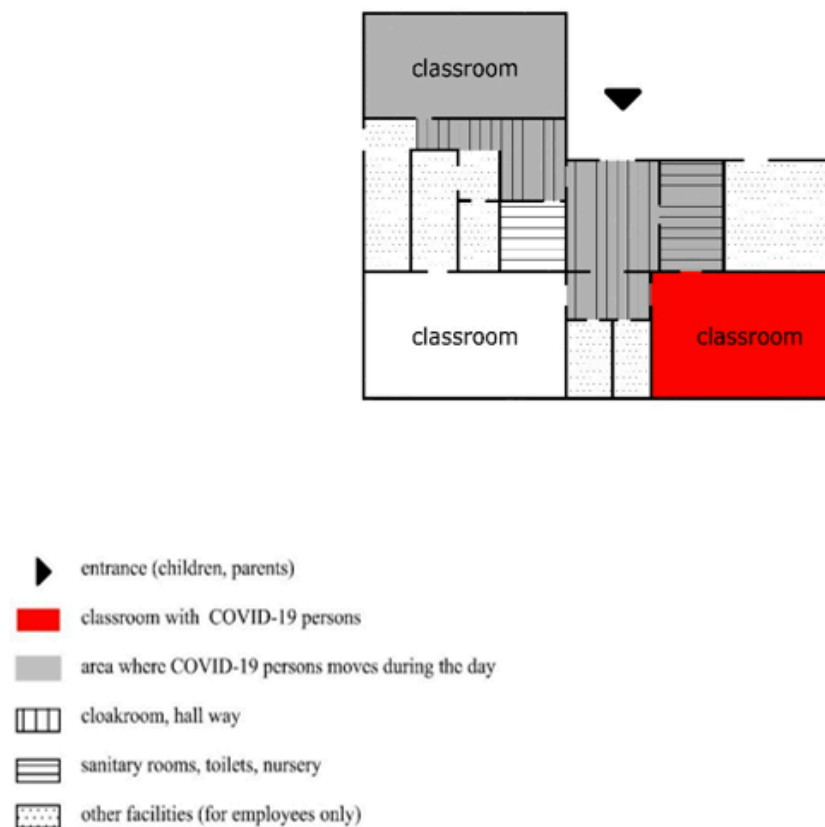


Figure 1. Content Kindergartens floorplans (kindergarten no.1, 2, 3, 4, 6, 7, 8, 9, 10, 11). Position of classrooms with COVID-19 persons and area where the COVID-19 person moves during the day.

4.3. Discussion

Eleven kindergartens with confirmed COVID-19 cases were analysed in detail. The cases were recorded over two weeks. Based on the analysed sample and on the assumption that all kindergartens followed hygiene and sanitary and organisational measures, our conclusions are as follows:

- In the analysed sample of buildings, more cases were confirmed among teachers (18) than among children (4).
- Only in three cases of the eleven analysed, children transmitted the virus to teachers.
- The virus spread within the kindergarten only in three cases of groups with younger children (aged 1–3), presumably due to closer contacts (lifting children when changing nappies, hugging, etc.).
- In practice, it turned out that the infection spread more frequently in small buildings (two to five groups). In small units, most rooms are common, and staff and children of various age groups cannot be separated.
- In large buildings (over 6 groups) with common entrances for three or four groups, toilets and staircases if buildings have several floors, all cases were confirmed in individual groups and did not spread within the building. Sharing cloakrooms, toilets, halls and staircases, and children mixing is inevitable in large kindergartens. However, it must be pointed out that, based on the analysed sample, we cannot conclude that large kindergartens are more at risk of the virus spreading. It must also be emphasised that preventive measures to contain the spread of the virus are more consistently followed in such buildings than in small buildings with an authentic atmosphere and contacts.

- Based on the analysed sample, other parameters, such as the number of children and density, do not show a special influence on the spread of the virus among children and staff in kindergartens (it was not established that the virus spread more in groups with more children).

On this basis, we can conclude that practice showed that functional units of large kindergartens can be divided, reducing the potential for contact between children in different groups. The spread of the virus between groups can be additionally prevented if hygiene and sanitary preventive measures are followed. Large buildings were designed with separate entrances for three or four groups, whereby the groups usually share cloakrooms and toilets. In smaller units with many common rooms (probably also because of more authentic contacts particularly among staff), the possibility for the virus to spread is higher. Based on the analysed sample, we can conclude that the virus spreads most among teachers and expert workers, but this is an epidemiological issue and not the subject of this research. In addition to the findings of this research, it should be pointed out that the issue of the spread of the virus among children (symptomatic or asymptomatic) remains unexplained and is not the subject of this research. However, this research speaks in favour of the fact that there was no transmission of the virus in the analysed sample.

5. Conclusions

It is becoming more than clear that COVID-19 is not just a public health crisis but one that touches every aspect of global society. The comprehensive strategy to minimise the impact of the virus on every aspect of society should be adopted. It is extremely important for kindergartens to remain open and provide a safe environment for children and staff. Kindergartens should be guided by a risk-based approach to maximise educational, developmental and health benefits for children, teachers, staff, and the wider community, and help prevent the spread of the virus. Therefore, buildings should be adjusted to the new circumstances.

The current research analyses the connection between the architectural characteristics of kindergartens and the spreading potential of the virus. The only conclusion related to the architecture of a building that should be pointed out is the fact that small kindergartens showed higher spreading potential due to numerous common rooms which small kindergartens usually have and where the users of buildings stay together. In addition, the question of the extent to which a more relaxed atmosphere and authentic contacts among staff, which are characteristic in buildings where the number of staff is low, contributed to this remains. The statement additionally indicates the importance of social circumstance, local and regional habits, and culture impact in the spreading of the virus in communities, and the conclusion is limited on the local region of Slovenia.

On the basis of the analysed sample, we can also state that larger kindergartens (the sample of this research included kindergartens with up to 16 groups) were not established as buildings with an increased risk of the spread of the virus if they followed preventive measures, as the functional design of buildings facilitated complete or partial separation of groups in the building. The separation of individual groups of staff with the functional design of a building is equally significant, since the analysed sample showed that the virus spread more among staff than among children.

The question of how to build in the future remains unclear and inevitable in the COVID-19 era due to the fact that the virus is still new and extensive research in different fields are being conducted worldwide to find out more about the virus. Many unanswered questions require further multidisciplinary studies. However, great attention should be paid on the possibilities of adjusting the existing kindergarten building stock to a the new COVID-19 era. The focus of the future research should be the question of what architectural changes to the existing building stock and future design should be to help minimise the spread of the virus and other diseases, and how to create an optimal environment for children's physical and mental health and well-being.

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