

# Home Office: Working and Studying Spaces in Residential Interiors during and after Forced Social Isolation

## Abstract:

The influence of global lockdowns during the COVID-19 pandemic has profoundly impacted the lives of many people. Once performed elsewhere, many activities had to be moved to private spaces of individual homes, influencing how people use their residential space, modifying their living and working conditions. The purpose of this study was to research the changes in the use of residential space through questionnaires addressed to respondents in five age groups (up to 25, 26–35, 36–50, 51–65, and over 65), and living or studying in the Milan area (Lombardy)—an area affected severely by COVID-19 in the period March–May 2020. The obtained questionnaire results allowed the authors to create a set of guidelines for apartment design, intended to improve their spatial performance. The observations made when creating the case study projects led to two main conclusions: First, at the level of the house plan, the arrangement of the plan should be free and adaptable, allowing for fast alteration by the user. Second, the project should be tailor-made, highly specialized, and purposefully designed at the level of home office design, including appropriate furnishings, technical appliances, and lighting systems.

Key words: residential architecture and interior design; social isolation; lockdown; COVID-19 pandemic; working and studying routines; creativity

## 1. INTRODUCTION

The influence of global lockdowns during the COVID-19 pandemic has profoundly impacted people's lives, changing them at the social, economic, and cultural levels. Many activities once performed elsewhere had to be moved into private spaces of individual homes, severely influencing the ways people use their residential space and, in many cases, worsening their living and working conditions (Nakada, 2020, 730). The research presented in this manuscript concerns adaptation to enforced social isolation and provides techniques and solutions to improve it. The results are expected to be relevant even after the end of the pandemic, as online professional activity will most likely remain popular. This research is based on the COVID-19 outbreak and restrictions implemented by the Italian Government from March 2020 onwards, and the research results underline the necessity of including a well-designed workspace in contemporary residential design—a subject that has been vastly overlooked, especially in smaller apartments. This study proves that negative opinions on smart working correlate with the lack of an adequate working environment at home. Lack of good architectural solutions influences professional decisions. This research also has an applied character, as we presented conceptual projects and realize a case study apartment to demonstrate them. Furthermore, this article concentrates mostly on the importance and efficiency of spatial arrangements. Influence of colors and materiality, although have a very important psychological impact on users were not the purpose of this research. The purpose of the initial part of the study was to understand changes in the use of space under lockdown

situations, as studied through questionnaires addressed to respondents in five age groups (up to 25, 26–35, 36–50, 51–65, and over 65) living or studying in the Milan area (Lombardy), an area affected severely by COVID-19 in March–May of 2020. We investigated how the respondents had coped with the necessity of living and working in restricted areas of their homes, how they perceived the experience, and how they have changed their living environment. Based on the responses given, we propose a set of guidelines for apartment arrangement. These guidelines were tested in conceptual projects. The obtained results are significant, as they can be applied not only in a pandemic context but in any situation when social separation or privacy is necessary. In conclusion, we confirm the relevance, adequacy, and benefit of applying the guidelines derived from analysis of the questionnaire. The questionnaire results and observation of case studies have led to two main conclusions: First, at the level of the house plan, the arrangement should be free and adaptable, allowing for fast alteration by the user. Second, the project should be tailor-made, highly specialized, and purposefully designed at the level of home office arrangement, with furnishings, technical appliances, and lighting systems are included.

## 2. STATE OF KNOWLEDGE

The current state of the knowledge indicates diverse ideas, predictions, and concepts regarding the effects of social distancing on interior design, architecture, and urban planning. An extensive overview, presented in "Antivirus-built environment: Lessons learned from COVID-19 pandemic" by Naglaa A. Megaheda and Ehab M.

Ghoneim (Megaheda, Ghoneim, 2020, 61), supported the prediction of highly profound spatial changes which pandemics cause in urbanism, public spaces, housing, office spaces, building, and construction technology. Suggestions of more divided residential interiors, combined with flexible spaces, can already be observed in the real estate market. An overview regarding aspects of sustainability in connection with COVID-19 has been described in "The problem of change in sustainability requirements" by Tokazhanov [Tokazhanov, Tleuken, Guney, 2020, 12]. In most articles, the dominating idea is that the built environment has a significant role to play before (prevention), during (containment and mitigation via segregation), and after (contingency planning and countermeasures for offsetting future risks) epidemics. Emerging evidence has pointed to the links between urban attribute-related individual activities and the risk of infection (Lai, Webster, Kumari, 2020, 27-31). In "How Architecture Fails in Conditions of Crisis: a Discussion on the Value of Interior Design over the COVID-19 Outbreak" [Rassia, 2020], Rassia S. has offered a dramatic vision of architectural failure in the face of the COVID-19 threat. We do not share such extreme beliefs. The willingness to remain as a community continues to fuel the attractiveness of city life, with high-density architecture and multi-apartment residential buildings. This does not mean, however, that nothing has changed. The change came with the strengthening of an already existing trend: smart-working. Partial adaptation to the new way of work seems to be the way out of many contemporary issues: Traffic, pollution, and stress. COVID-19 has become one more argument for working from home, when possible. With this opportunity comes, however, one major problem in creating high-quality environments for vast populations of people: until now, creating an optimal working space was the domain of architects and interior designers employed to produce ergonomic working conditions in office buildings professionally. Now, this task is in the general public's hands, which has to adjust private apartments, in which workspaces have typically not even been foreseen. Non-ergonomic, unprofessional solutions can create serious health risks and, as a result, decrease work efficiency. For this reason, the authors of this manuscript consider working space at home the essential aspect of this change. Our working hypothesis consists of the following:

- Private apartments are insufficiently equipped to serve smart working;
- It is possible to define a set of guidelines and design points to improve their performance;
- There is a relationship between the working conditions at home and acceptance of the concept of smart working.

According to Google Scholar, the number of peer-reviewed articles concerning interior design, architecture, and urban design during pandemics was 422,000<sup>1</sup>, making it a mainstream topic in the field. For the authors, it was crucial to include ongoing discussion sources of

information, such as recent documents, news, and expert opinions expressed online on thematic websites. The image appearing in the bibliographical research is highly complex. The reviewed conceptual models included many variables, most of which were related to factors directly affecting the health of the inhabitants (Jensen, 2020, 95-112), such as air humidity (Psomas, Teli, Langer, 2021, 198), noise (Szczepańska, Senetra, Wasilewicz-Pszczółkowska, 2020, 801), lighting (Moadab, Olsson, Fischl, 2021, 244), and the thermal environment (Jung, Yoon, 2017). Particularly noteworthy are the studies by Kadhim and Ubaid (2021, 1067), which dealt with the impact of a pandemic on the perception of architectural interiors by people who are isolated for a long time and exposed to stress from epidemiological threats. At the same time, attention has been paid to the arrangement of rooms, which promotes physical activity, as a factor which is beneficial to mental and physical health. According to WHO data, sedentary lifestyle is a significant risk factor for obesity, chronic diseases, and premature death (WHO, 2018). In this context, the interesting model of "Active design" has been presented by Engelen (2020). "Active design" is a new concept of integrating physical activity into daily life through appropriately designed residential interiors.

The discussion regarding safety concerning apartment size and plan is also necessary, because of the more and more widespread phenomenon of flat-sharing; visible, particularly, in a global metropolis. Apartment sizes and layouts should support physical distancing for shared dwellings, according to national health guidelines. The maintenance of physical distancing between residents should be considered, in order to establish comfort and safety within shared dwellings. YouGov, a British online survey<sup>2</sup>, found that 31% of adults have experienced mental or physical health issues due to the quality of living conditions within their homes during lockdown. Furthermore, the survey indicated that 30,000 Britons had spent their time during city lockdowns in one-room dwellings. In this context, avoiding tiny, sub-standard dwellings and employing flexible housing solutions that can support self-isolation within shared units could become critical in containing the spread of diseases. Employing good maintenance routines, ICT technologies, and touch-less solutions from the entrance to the apartment door can improve hygiene and safety (Peters, Halleran, 2020, 10-27). Technology can support social distancing and provide users with contactless access, through mobile solutions, voice-enabled solutions, or gesture detection technologies. It is possible to identify and authenticate individuals for quarantine purposes using sensors to measure biometrics such as voice, iris images, facial features, and behavioral characteristics (Priday, 2020). Finishes made of materials limiting the growth or spread of microorganisms can be used in the interiors of public areas within multi-story residential buildings. From an architectural standpoint, anti-contagion solutions could also include wider corridors and doorways. It is also essential to provide adequate ventilation in both the common areas and private dwellings. In multi-story buildings, water and air

filtration systems should be applied as a standard. The comfort level should be improved, reassuring natural sunlight in living areas and access to greenery; conditions purely depending on city planning. Indoor gardens should be encouraged (Belzunegui-Eraso, Erro-Garcés, 2020, 3622; Marr, 2020).

Separately, there is an emerging body of research pointing to the benefits of shifting work from office buildings to apartments in the wake of the COVID-19 pandemic. The online working modality is a relatively new way of performing professional activities, with the earliest predictions dating back to the 1970s (Toffler, 1970). However, for good, work from home emerged in the early 2000s, when information and telecommunication technologies (ITC) became widely accessible. As a result, employees could work from home (WFH), in order to avoid commuting, provide flexibility in schedules, and improve work–life balance. One of the predictions related to the COVID-19 outbreak is the high probability that, even after periods of forced social isolation, many will continue to work from home. With the spread of COVID-19, most companies have adapted the WFH concept, to some extent: some permit only a few days of smart working, while others allow for a complete change of working modality (Priday, 2020).

As Frumkin (2020) has noted, studies in large corporations in the U.S. show that employees are more productive when working from home and, at the same time, there exists potential for significant savings by reducing office space. Petersen (2020) has noted that, in fact, people do not want to return to the office due to the realized inconveniences: The long commute, wasting time in too many meetings and conferences in the office, the mad rush and stress in the workplace, and having to eat meals out that are not always healthy. The numerous benefits of moving work from the office to the home have been indicated in a report by the consulting firm PwC (2020). According to this research, by July 2021, 75% of executives anticipated that at least half of office workers would be working from home. In comparison, 61% of employees expected to spend half their time in the office by July 2021. A June 2020 survey in the U.S. confirmed that remote working has been a huge success for both employees and employers: 83% of office workers said they were willing to continue working from home at least 1 day after the pandemic, including 32% who wanted to work from home full-time (PwC, 2021). As the pandemic unfolded, major U.S. employers, such as Facebook, Google, and Twitter, announced plans for long-term, large-scale shifts toward telecommuting (Wakabayashi, 2021). Overall, the pandemic experience has offered a number of lessons that will change the relationship between the workplace and the home in the years ahead (Capolongo, Rebecchi, Buffoli). Tompkins (2020) has emphasized that this triggers an urgent need to develop new architectural design models for residential interiors, in order to make them healthier, more sustainable, and more resilient than ever before.

The transition from structured office environments to home-based, virtual, flexible work arrangements is

expected (Tompkins, 2020). The evolution of plans of residences to include a home office is already happening (Alter, 2020). Working from home requires privacy and acoustic comfort; for example, to hold virtual meetings. As a result, a tendency for creating fixed sub-divisions, thus diminishing the surfaces of long-popular open-plan arrangements, has gained in popularity. In many cases, the entrance area could be separated from the living room to create a buffer space for sanitizing hands, taking off potentially contaminated shoes, and leaving used clothing outside. The dining room, if not connected to the living room or kitchen, may be used for video-conferencing. Flexible internal compositions can enable many modalities of using the same space. Furniture that offers adaptable configurations supports different activities, and kinetic interior elements can be introduced.

Access to external space, nature, and greenery has proven vital during forced social distancing. The biophilic design approach, which has already been used within the building industry to increase connectivity to the natural environment, can have a new substantial scope: improving psychological conditions for those spending much time in the enclosed spaces of their residences. Biophilic interior design, apart from including natural greenery within the work environment, can reach beyond the limits of the room and aim to visually include the landscape or green external space. Permanent access to a garden, terrace, or balcony releases stress and encourages breaks during work<sup>3</sup>.

A natural consequence of COVID-19 is the vision of a single-family house as an optimal way of living in the post-pandemic era. The pandemic has supported the concept of detached housing with surrounding gardens and possibly even individual food production as a form of living that offers separation and privacy, while diminishing the probability of encountering others. In this building typology, it is possible to include separate water supply and heating (with parallel solutions), through the use of geothermal wells, a stove, a fireplace, a fuel boiler, a fuel generator, or solar panels. Of course, a detached single-family house cannot be a solution for everyone who lives in a city, but only a small group of the privileged. Therefore, we considered researching how to facilitate safe, ergonomic workplaces in apartments located in multi-story residential buildings as the most urgent task, providing reason for undertaking the subject presented in this manuscript.

### 3. MATERIALS AND METHODS

The method used in this research is quantitative; based on a multiple-choice questionnaire. The study was divided into three stages, as presented in the methodical scheme shown in Figure 1:

1. A questionnaire was issued to 226 persons concerning the first lockdown in Italy (March–May 2020). Respondents were divided into five age groups (up to 25, 26–35, 36–50, 51–65, and over 65) and lived (permanently or temporarily) in the Milan area (Lombardy). The group was subjected to the same type of restrictions imposed by the Italian

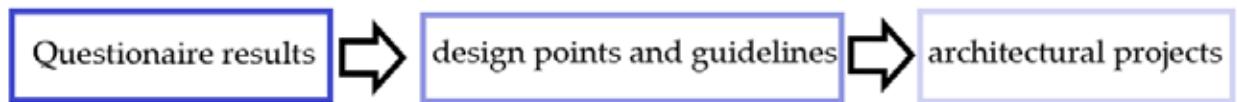


Fig. 1. Methodical scheme.

Government. Each participant was tested individually, having no interaction with the others. All study participants were informed prior to study initiation that they would be participating in a study investigating the effects of pandemic insulation on living space use. The questionnaire results are detailed in Section 4.1.

2. The definition of design points and guidelines derived from the questionnaire results are shown in Table 1 (Section 4.2).
3. Examples of the application of design points and guidelines in architectural projects are given in Chapter 5.

Ad. 1. The questionnaire was divided into four specific topics corresponding to typical actions undertaken at home: working and studying (1), physical activity and sports (2), cooking and eating (3), and leisure and entertainment (4) (Bonenberg, Lucchini, 2021, 10). The questionnaire started with a general section featuring questions regarding the size of the residence in which the person resided, residence typology, and its internal arrangement. For the full list of questions, please refer to Appendix A. The Working and Studying section examined the necessity of starting or increasing the work done from home. Questions regarding the amount of time spent working from home, as well as the participant's intentions regarding the continuation of working or studying partially or even entirely from home after the pandemic were asked. Inquiries were also made regarding the physical space in which work or study was performed, such as a separate studio, living room, bedroom, kitchen, or garden. The sufficiency of the space and applied means of improvement were investigated. A descriptive question regarding a perfect workplace was posed. The paragraph regarding *Physical Activity and Sports* focused on how the fitness routines of participants were affected by the lockdown. Questions regarding the amount of time spent on physical activities and sports at home were asked, combined with an inquiry regarding spaces in which they were performed (private gym, living room, bedroom, garden, balcony). The sufficiency of space for physical activity and possible improvements in the workout space also belonged to this area of interest. Inquiries regarding their willingness to continue sports routines at home after the pandemic were made. The paragraph *Cooking and Eating* concentrated on culinary habits and consumption culture. During the pandemic, the possibilities of eating out became subject to limitations; on the other hand, families tended to spend more time together, eating and often cooking collectively. Therefore, changes and adjustments in the kitchens and dining areas to new routines were analyzed. Finally, the section *Leisure and Entertainment* featured

preferred types of entertainment during the COVID-19 lockdown and the kinds of space that respondents used for the purpose. In this paper, we concentrate on presenting the results of the Working and Studying From Home section as the most critical area.

## 4. RESULTS

### 4.1. Questionnaire Results

Data obtained from the questionnaires were quantified, cross-referenced, and analyzed. A total of 78% of respondents declared that they had to switch to online working or studying. Most people claiming that they did not switch to online activities were in the age group over 65 years old. Even though social isolation caused negative feelings of anxiety or annoyance, it seems that the experience was not entirely negative, as only a minority (43%) of respondents would prefer to go back to exclusively in-presence work or studying. This result indicates that the COVID-19 pandemic has stimulated a trend that is probably here to last. A total of 57% of the group stated that they would like to continue working and studying in a hybrid way. Furthermore, 17% declared that they would like to stay entirely online (Bonenberg, Lucchini, 2021, 13). This could mean that moving activities online is not merely a response to a short-lasting emergency.

There is evidence that openness to smart working is related to the conditions in which one works. Respondents who perceive their current home working space as sufficient to their needs are more open to the online working experience, both at present and in the future. In the group who positively answered the question "Is your working space sufficient?", 68% wished to continue working or studying partially from home after the emergency finishes; in contrast, in the group declaring their working conditions to be insufficient, it was only 54%. The comparison between the two groups is presented in Figure 2.

Spatial changes in apartment design are worth considering, as they shape people's decisions regarding their work modality. Living conditions which are adequate when working purely outside the home may become sub-standard when work starts to be carried out in the place of residence. This situation raises questions regarding introducing building guidelines advocating the inclusion of work spaces. The tendency for choosing larger flats or family homes is already visible in data from immobility markets since the pandemic started. The additional space has become more appreciated. It probably will take time to popularize the idea that a well-designed studio, home-office, or at least enclosed working space is essential from now on. Curiously, individual assessment of self-organized working space

WOULD YOU LIKE TO CONTINUE WORKING OR STUDYING PARTIALLY FROM HOME AFTER THE PANDEMIC?

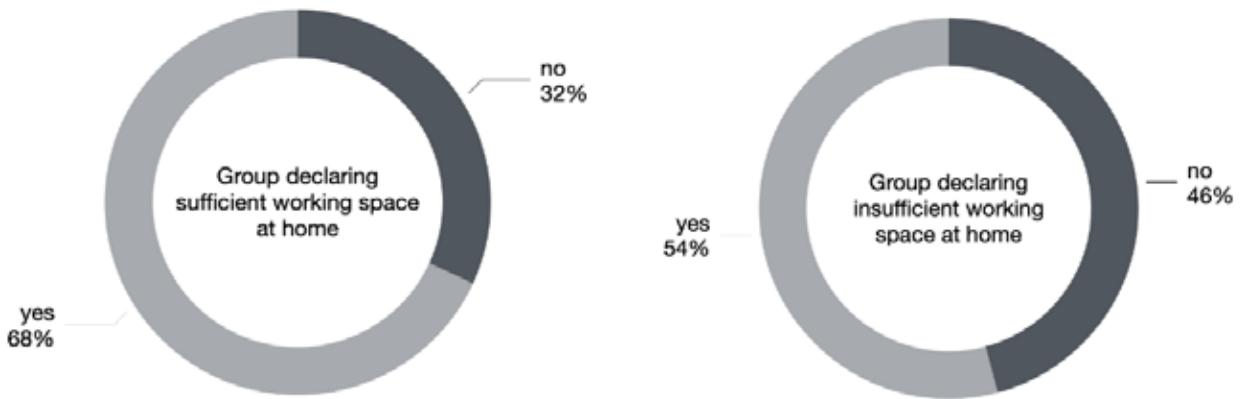


Fig. 2. Comparison between groups with sufficient and insufficient home office space regarding willingness to continue working or studying partially from home after the pandemic. After: Bonenberg, Lucchini, Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors.

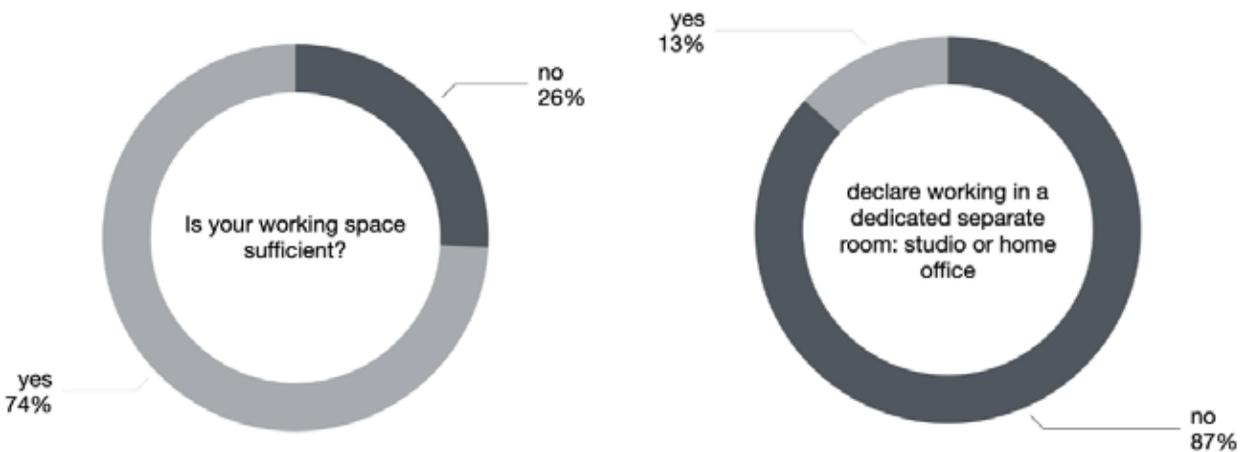


Fig. 3. Comparison between the number of people declaring sufficiency of working space and those who work in a dedicated studio or home office. After: Bonenberg, Lucchini, Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors.

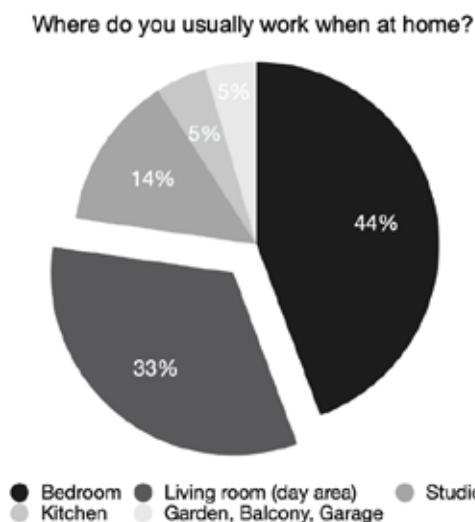


Fig. 4. Distribution of spaces in which respondents work from home. After: Bonenberg, Lucchini, Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors.

tended to be high. When asked about the sufficiency of working spaces, 74% declared that their space was sufficient, even though only 13% had a separate studio room. A comparison between the two groups is presented in Figure 3.

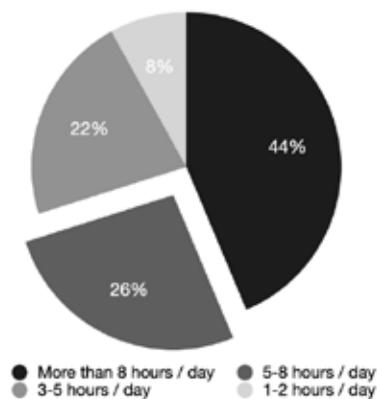
This observation indicates that the general public has not yet recognized the need for a high-standard workspace. Homemade “working corners,” apart from being far from comfortable, can bring health risks to the user. On the other hand, work performed from the bedroom or living room can be productive and does not have to present health risks, only under the condition that work organization, furnishings, and lighting systems follow ergonomic roles, as professionally arranged office spaces in office buildings do.

When asked about where they work at home, respondents most frequently pointed out bedrooms (44%), living areas (33%), kitchens (5%), and external spaces such as a garden, balcony, or garage (5%). These results are represented in Figure 4, and indicate that a set of guidelines to set up high-quality working spaces could be essential to introduce and popularize.



Fig. 5. Photographs of home-arranged working spaces. A,B- chaotic home-office space, C- home-office space arranged in a bedroom, D-temporary home-office space arranged in a garden.

How much time did you spend working from home during COVID19 emergency?



What would you improve in your working space at home?

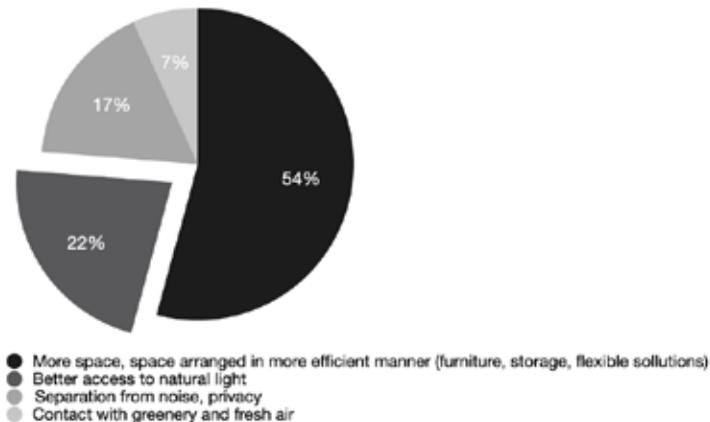


Fig. 6. Distribution of average work time at home during the COVID-19 lockdown. After: Bonenberg, Lucchini, Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors.

Fig. 7. Workspace improvements which respondents would like to introduce in their homes. After: Bonenberg, Lucchini, Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors.

Some of the respondents supplemented their questionnaires with photographs illustrating home-arranged workspaces (see Figure 5). Examples of the attached photos are shown below, and can be treated as extra insight into the randomly arranged situations. Apart from examples A and B—which are separated studios—C (bedroom) and D (garden) represent random conversion and adaptation to work purposes.

The problem of ergonomics in home-arranged workplaces is significant, due to the very long time that respondents claimed to spend there: 44% claimed that they worked at home more than 8 h a day, and a further 26% reported 5–8 h (see Figure 6). As a result, a healthy working environment is of crucial importance. The correct chair height, adequate equipment spacing, light, and good desk posture can help to keep a healthy routine. In professionally designed and equipped offices, solutions have to meet the standards (Hossam, Zaher, 2020, 117-133); however, in home-constructed ones, this is not necessarily the case. Respondents were asked about that changes that they would introduce in their workspace at home. The respondents claimed that they would enlarge or rearrange the working or studying space at home (54%), and indicated better access to natural light (22%), separation from noise, and more privacy (17%) as essential (but lacking comfort) factors (see Figure 7). It is worth underlining that issues such as more sun or greenery in front of windows (as indicated by 7% of respondents) are related to decisions concerning urban planning. For this reason, we took these issues into consideration.

#### 4.2. Design Guidelines Deriving from Questionnaire Results

Based on the questionnaire analysis results, when arranging or refurbishing working or studying areas, the guidelines listed in Table 1 should be taken under consideration. Interconnections between the design guidelines deriving from questionnaire results are also presented. Design guidelines deriving from the questionnaire results were implemented into case study apartments, as presented in Chapter 5. The elements and products used in

these projects are listed in Table 2. It is worth underlining that the necessity of working from home fuels new needs in furnishing and interior design products. Elements previously characteristic of office design now have their application in the household. The most characteristic elements marking this trend are fixed and movable walls, fixed and movable acoustic panels, transparent divisions for acoustic separation, ergonomic furniture systems, specialized office lighting systems, plant exposition systems, and green walls for interiors and exteriors.

### 5. USING RESEARCH RESULTS IN EXEMPLARY ARCHITECTURAL PROJECTS

The design points and guidelines derived from the questionnaire results listed above have inspired architectural projects (McKeown, 2007) (Biggs, Büchler, 2008). The initial concepts of workspaces within apartments are concentrated in two aspects:

- General comfort and wellbeing in flexible home working environments; and
- Possibility of safe work and quarantine at home in an unfortunate case of contagion of a family member.

The apartment plan, which was chosen to create initial concepts for the project, is located in a multi-story residential building with a predominant southern exposure, featuring three long balconies. It can be treated as an average example characteristic of the northern Italian building tissue of the 1970s<sup>4</sup> with a structural system of reinforced concrete beams and columns, allowing for changing of the positions of internal walls. The total usable surface is 116 m<sup>2</sup>. In the original plans (before renovations), the apartment consisted of a long entrance corridor, a centrally positioned storage room, a separated kitchen, a living room, two children's bedrooms, a master bedroom, and two bathrooms. The new design aimed to simplify and open up the floor plan; which, in its original version, divided the space into a complex sequence of small rooms. There had been a decision to demolish the central storage room; as such, a vast entry corridor has been created. In addition, the kitchen

Table 1. Design guidelines deriving from questionnaire results.

Questionnaire Results	Design Guidelines Deriving from Questionnaire Results
13% of respondents work in a separate studio room	As most households cannot guarantee a separate room for a home office, it is essential to find and arrange a location to provide as much visual and acoustic separation as possible. Flexible, movable interior elements, walls, and curtains should be considered. Furthermore, it is crucial to take under consideration the main possible views and backgrounds for video-conferencing.
44% of respondents work from bedrooms 33% from living areas 5% from kitchens 5% from external spaces like a garden, balcony, or a garage	Working or studying spaces are being developed in diverse areas of homes. This strategy can be successful if these “pop-up” office spaces are arranged not to collide with other activities. Their various locations can help overcome the monotony and support of advised regular breaks in screen time, especially in external spaces such as gardens or balconies.
44% of respondents work at home more than 8 h a day 26% of respondents work at home 5–8 h a day	Due to the long work hours, a fully ergonomic working environment becomes necessary. The correct chair heights, adequate equipment spacing, sufficient storage, well-adjusted artificial illumination, and natural light become important. All furniture and computer positions have to meet ergonomic standards, as in a professionally designed office.
54% of respondents wish for more office space or space arranged in a more efficient manner	Usage of flexible furniture equipped with an abundance of storage and workspace should be proposed. Within a home office, arrange task areas with an adequate hierarchy: main working space with computer station, creative worktops for drawing and writing (if needed), reading/relaxing area (preferably combined with a library), and external working space (e.g., on the terrace) to avoid monotony.
22% of respondents wish for better access to natural light	Prioritizing spaces with natural light, locating working areas close to windows, and providing adequate intensive artificial illumination are crucial. Using mirrored walls opposing windows enhances the sensation of natural light in the room. Light colors are also advised. Additional sources of light are necessary for video-conferencing or registering video materials. For this, an effective blackout system (curtains, shutters) may also be necessary.
17% of respondents wish for separation from noise and more privacy	Acoustic panels should be applied on walls when adapting rooms for working/studying areas. In the case of using separating panels, a product with a soft finish should be chosen, in order to reduce noise.
7% of respondents wish for more greenery and fresh air in their home-office area	Whether converting a room into a home office or setting it up in other living areas, it is good to establish visual or functional connections with external spaces (garden, balcony) filled with natural greenery. It is essential to give an opportunity to take breaks outside. To enforce this connection, it is also possible to use natural greenery as an interior design element.

Table 2. Design points and declared interest, according to the questionnaire, combined with elements and products for implementation in the case study apartments presented in Chapter 5.

Design Points	% of Respondents Declaring Interest According to the Questionnaire	Elements and Products for Implemented in Case Study Apartments Presented in Chapter 5
Enclosed compartment areas and working spaces	87%	Furniture systems integrated with dividing walls and panels (Figures 10 and 11) Dividing fixed and movable walls and panels (Figure 14) Transparent divisions for acoustic separation (Figures 19–21)
Furniture	54%	Ergonomic furniture systems adjustable to the body measures of the user (all projects) Organization of office elements (all projects) Specialized office seating (all projects) Specialized storage compartments for office work working space with computer station, creative worktops for drawing and writing, reading/relaxing area, preferably combined with a library
Light, connection to the exterior	22%	Location of working space close to windows (Figures 15–18) Specialized office lighting system (all projects) Specialized light for video-conferencing or registering video materials (all projects)
Greenery	7%	Plant exposition systems, green walls for interiors and exteriors, aquariums (Figures 19–21)
Acoustics	17%	Acoustic panels for interiors and exteriors (Figures 15–18), acoustic soft division walls (Figures 12 and 13)

and living room were combined, creating an ample, luminous space. These initial changes in flat design have become the basis for developing several project proposals. Changes and adjustments support self-sufficient strategies that can be applied in the case of lockdowns, but are also helpful for intensive-use home offices or home studying. Design concepts presented in

this paper have been designed at the Faculty of Architecture, Poznan University of Technology.

The first approach concentrated on the basic idea of creating a flexible apartment design, including six different setups:

- Basic setup (see Figure 8);
- Pop-up home office setup (see Figure 9);

- Two workout setup options (see Figures 10 and 11); and
- Two self-isolation setup options (see Figures 12 and 13).

The basic setup caters to the needs of all household members. Upon entry, it has a disinfection area and outerwear storage, equipped with washing and disinfection stations. There is also uninterrupted access to a bathroom to wash before entering other rooms of the apartment. The apartment has been separated into two private zones, with a living/dining space in its center. The division between night and day zones has also been preserved. In addition, the balconies are arranged in such a way to provide dining and resting spaces. They have also been equipped with vegetable pots and herb racks, to ensure the possibility of food production and relaxation. This setup can easily be used during and outside of lockdown periods.

The home office setup aims to provide a private online working space for every household member (see Figure 8.). The master bedroom has been equipped with a Murphy bed with a folding desk on the other side. A second online working station can be arranged in the former dining area, transforming the table into a height-regulated working station. A sliding sound-proof wall can also shut off this area, to ensure privacy. Finally, in the north bedroom, an online schooling station for children has been provided.

The workout setup aims to support the training routines of the users (see Figure 9.). It provides two areas with foldable benches and mirrored wardrobes with workout equipment. These areas can be used for fitness, yoga, stretching, weight lifting, calisthenics, Pilates, and more. The spaces are well-ventilated, to ensure enough airflow and to keep smells away. After training, the equipment can be folded away to restore the rooms to their original setups.

Self-isolation setup 1 (see Figure 10) aims to provide an isolated living space for a child during illness. It ensures individual access to the bathroom, bedroom, and dining space. Meals and medicines can be provided through a balcony window, in order to prevent the transmission of viruses to other household members. The only common area with the rest of the apartment is the entry corridor/disinfection area, which can be cleaned if necessary.

Self-isolation setup 2 (see Figure 10) aims to provide an isolated living space for one of the spouses during illness. It also ensures individual access to one bathroom, bedroom, and an outside dining space. During the infection period, the other spouse can occupy a temporary bedroom that can be created at the place of the former dining area. It has a Murphy bed and a height-regulated working desk. This room can also be used by visitors when the emergency finishes.

From questionnaire results presented in Section 4.1, we found that, in the unexpected situation of the first lockdown (March 2020), home offices were created in random areas in the house—very often in bedrooms,

living rooms, or even garages. Following these spontaneous decisions of users, flexible, pop-up office areas arose. From these, there arose proposals of add-on areas within main bedrooms that can accommodate desks or even additional beds in the case of sickness, which were considered in the design phase. The spaces can be separated from the main room with a transparent acoustic wall and a drape for visual separation when video-conferencing (see Figures 11–18). Research has indicated that working from home has a substantial impact on the relationship between professional and private lives. The once-firm boundary guarded by the four walls of private residences has been overcome. An apartment in which one performs professional activities should be designed to encourage work–life balance (see Figures 15–17). It is crucial to create a sense of psychological separation between “work time” and “home time,” as distance and real space do not separate these realities anymore. The proposal to address this matter includes a wide variety of activities performed in visually different setups. Changing activities and environmental behavior is a behavioral strategy to improve the comfort of work and life–work balance.

## 6. DISCUSSION

The pandemic lockdowns have served as an important, large-scale test on housing environments throughout the world. Never in modern history have so many people been forced to change their modality of living and working on such short notice. Consequently, the pressure for apartments and houses to be adapted quickly was strong, but this has not always led to successful results. Therefore, flexibility and adaptability are vital in housing design. The historical discussion present in the research and writings of John Habraken (1998) regarding design and construction modalities of ‘open building’ becomes, in this context, of key importance (Nascimento, 2012). An approach that foresees the possibility of extensive user involvement in the making and changing of space supports the idea that design is a process involving multiple participants, not being limited only to professionals. Furthermore, as the recent lockdowns have proven, Habraken’s concept regarding *change* has become a reality for many households. The need for distinct intervention levels in the built environment, represented by ‘support and ‘infill’, remains very pertinent. Flexibility can manifest itself not only in the medium-to long-term, through well-elaborated structural systems, but also in day-by-day performance. Two modalities can be applied (Bonenberg, 2018):

- Flexibility through *reconfiguration* of interior elements (Kinetic Architecture); and
- Flexibility through changes in the functional division of space (Negotiation between functions around fixed elements in the interior).

Reconfiguration of the architectural space denotes the possibility of multiple redefinitions of parameters for the functional division, based on the mobility of

architectural elements or the elements of interior design. Changes associated with spatial reconfiguration take place in the short- or medium-term time-frame (Fox, Kemp, 2009). One of the first and basic examples of creating a kinetic, re-configurational residential interior was the historic villa Schröder by Gerrit Rietveld (1924), and later observed in LeCorbusier and Pierre Jeanneret Weissenhof-Siedlung Houses 14 and 15 (1927), Eames House (1945), Shiheru Ban Wall-less house (1997), and Solid Cedar House (2015). Examples continue to appear to present. The second case study project (Figures 14–18) presented in this paper provides an example of the use of movable panels and layers of curtains to create a separate home office space.

In contrast, negotiation in architectural space denotes the ability to redefine the functional separation, which takes place in a short period. Spaces for negotiation are created around static compositional systems, designed such that the space can be used in many ways (Bonenberg, 2018). Thus, negotiation in architectural space means the ability to change the proportion of space occupied by a particular function for a short (or moderately short) period.

In contrast to re-composition, it does not consist of generating physical changes in a given space. In practice, designing negotiative space is connected with the arrangement of an open plan around fixed functions, such as stair risers, bathrooms, and kitchen. Classic examples of this approach are Farnsworth House by Mies van der Rohe (1950) and Glass House by Philip Johnson (1947) (Volner, Johnson, 2020). These historical examples have led to the popularization of the “negotiating” space in newly designed buildings, especially with the concepts of the spatial negotiations converging, in many points, with the slogans of minimalism (Nebois, 2003, 680). An attempt to use such an approach can be observed in the first case study (see Figures 9–13).

Theories and good-practice solutions observed throughout the world regarding flexible solutions in architecture have rarely entered into mainstream realizations. Being seen as a peculiarity, they have been seldom applied in average housing; or, at least, not in the areas covered by the conducted research. Based on questionnaire results, homes have widely failed during the pandemics, regarding the dimensions and arrangement of spaces: 54% of respondents complained about little or ill-organized workspace. Flexibility and adaptability seem to need to be applied vastly in house plans.

However, when it comes to the execution of the home office with dedicated furniture, accessories, and lighting, the design must be well-tailored to the context of the individual. This approach was presented in the case studies detailed in Chapter 5. The projects were developed in a detailed manner, in order to anticipate the needs of users and their comfort when using the space available to the fullest. It is true that, in light of Habraken’s concepts, this could be considered

“overdesigned.” In our view, however, the home office has now acquired the position of the most important specialized function of the house. Those who perform smart working have now realized that. For this reason, the design approach, attention, methods, and tools should change and become more similar to another, very specialized house area; namely, the kitchen. The general public has already acknowledged the value of ergonomics, technological advancement, and aesthetics of kitchens—and their consequent impact on house prices. It is high time that analogical measures were applied to home office design. The arguments for such are strong:

- The questionnaire results suggested that respondents spend a lot more time working than cooking (44% claim that they work at home more than 8 h a day, and a further 26% work 5–8 h);
- Activities performed in both areas are very different, but similarly diverse; and
- Both areas include specialized equipment: in the case of the home office, computers, printers, video-conferencing areas with specialized illumination, and many other optional elements are required, depending on the work performed.

## 7. CONCLUSIONS

The concept that the built environment is constantly transforming and that the associated changes must be recognized and studied (Habraken, 2009) has made the consequences of the COVID-19 pandemic an important research theme for urban planning, architecture, and interior design. The theories of contemporary architecture provide tools, concepts, and approaches to adjust the built environment to changes. This adjustment can be seen as a contemporary attempt to address Vitruvian durability. There are also many historical and contemporary buildings in which resilience to change through flexibility has been successfully applied. Our research, conducted in Lombardy through the issuing of questionnaires, demonstrated that introducing changes in the average dwelling is challenging; however, the need for change is substantial (54% of respondents would enlarge or rearrange their working space, 22% would have better access to natural light, 17% better separation from noise and more privacy, and 7% access to greenery and fresh air). The possible answers to these needs were researched through case study projects, leading to two main conclusions or observations valid for both existing and newly designed apartments. First, at the level of the house plan, the arrangement should be free and adaptable, allowing for fast alteration by the user. Second, the project should be tailor-made, highly specialized, and purposefully designed at the level of home office arrangements, containing appropriate furnishings, technical appliances, and lighting systems. Above all, home office areas should be finally given the attention they deserve, in the eyes of both designers and the general public.

## Appendix A

Table A1. List of Questionnaire Questions

0.	<p><b>GENERAL INFORMATION</b>            How many square meters has a residence in which you have spent COVID-19 lockdown?            In what type of residence have you spent COVID-19 lockdown?            How is your house arranged? How did you feel about the lockdown and social distancing situation?</p>
1.	<p><b>WORKING AND STUDYING FROM HOME</b>            Did you have to start to work or increase the amount of work or studying done from home because of the COVID-19 lockdown?            How much time do you spend working from home during COVID-19 emergency?            Would you like to continue working or studying entirely from home after the emergency finishes?            Would you like to continue working or studying partially from home after the emergency finishes?            Where do you usually work at home?            Is your working space sufficient?            What would you improve in your working space at home?</p>
2.	<p><b>PHYSICAL ACTIVITY AND SPORTS</b>            Has COVID-19 lockdown affected your physical activity and sport routines?            How much time do you spend on physical activities and sports at home during the COVID-19 lockdown?            What kind of activity do you choose, and what kind of space do you use to perform it?            Is the space you use currently sufficient for physical activity in the COVID-19 lockdown situation?            What would you improve in your workout space at home?            What should your perfect home workout space at home look like?            Will you keep the routine of home exercise even after the emergency finishes?</p>
3.	<p><b>COOKING AND EATING AT HOME</b>            Has COVID-19 lockdown affected your eating and cooking habits?            How to adjust your kitchen and dining area to better meet the new demands?            Will you keep the new cooking/eating routine after the emergency finishes?</p>
4.	<p><b>LEISURE AND ENTERTAINMENT</b>            What are your main three types of entertainment during COVID-19 lockdown?            What kind of space do you use to entertain yourself or the persons you live with?            How would you improve the entertainment spaces in your home?            Will you keep the new leisure routine after the emergency finishes?</p>

### ENDNOTES

- <sup>1</sup> Google Scholar Search Results. Available online: <https://scholar.google.com/> (accessed on 3 July 2021)  
<sup>2</sup> You Gov: <https://yougov.co.uk/topics/economy/articles-reports/2020/09/22/most-workers-want-work-home-after-covid-19> (accessed 15.11.2021)  
<sup>3</sup> <https://www.archdaily.com/936064/is-coronavirus-pandemic-accelerating-the-digitalization-and-automation-of-cities> (accessed on 25 April 2020).  
<sup>4</sup> Analisi dell Costruito, Comune di Genova, 2011. [http://puc.comune.genova.it/03\\_11\\_2014/DEF/1\\_DF/1\\_10\\_doc.pdf](http://puc.comune.genova.it/03_11_2014/DEF/1_DF/1_10_doc.pdf), (accessed on 23 July 2021)

### REFERENCES

- [1] Nakada, L., 2020, Urban, R. COVID-19 pandemic: Impacts on the air quality during the partial lockdown in São Paulo state, Brazil. *Sci. Total Environ.*, *730*, 139087.  
 [2] Megaheda, N.A., Ghoneim, E.M., 2020, Antivirus-built environment: Lessons learned from Covid-19 pandemic. *Sustain. Cities Society*, *61*, 102350.  
 [3] Tokazhanov, G.; Tleuken, A.; Guney, M.; Turkyilmaz, A.; Karaca F., 2020, *How is COVID-19 Experience Transforming Sustainability Requirements of Residential Buildings? A Review*. *Sustainability*, *12*, 8732.  
 [4] Lai, K.Y.; Webster, C.; Kumari, S.; Sarkar, C., 2020, *The nature of cities and the Covid-19 pandemic*. *Curr. Opin. Environ. Sustain.*, *46*, 27–31. Available online: [www.sciencedirect.com](http://www.sciencedirect.com) (accessed on 25 August 2021).  
 [5] Rassaia, S., 2020, *How Architecture Fails in Conditions of Crisis: A Discussion on the Value of Interior Design over the COVID-19 Outbreak*. In *SN Operations Research Forum*; Springer International Publishing: New York, NY, USA, Volume 1.  
 [6] Jensen, A.; van der Voordt, T.J.M., 2020, *Healthy workplaces: What we know and what else we need to know*. *J. Corp. Real Estate*, *22*, 95–112.  
 [7] Psomas, T.; Teli, D.; Langer, S.; Wahlgren, P.; Wargocki, P., 2021, *Indoor humidity of dwellings and association with building characteristics, behaviors and health in a northern climate*. in. *Build. Environ*, *198*, 107885.  
 [8] Szczepańska, A.; Senetra, A.; Wasilewicz-Pszczółkowska, M., 2020, *The Influence of Traffic Noise on Apartment Prices on the Example of a European Urban Agglomeration in Sustainability*, *12*, 801.  
 [9] Moadab, N.H.; Olsson, T.; Fischl, G.; Aries, M., 2021, *Smart versus conventional lighting in apartments—Electric lighting energy consumption simulation for three different households*. in *Energy Build*, *244*, 111009.  
 [10] Jung, S.; Yoon, S., 2017, *Deduction of Optimum Surface Design Factors for Enhancement of Outdoor Thermal Environment in a Micro-Scale Unit*. in *Sustainability*, *9*, 1381.  
 [11] Kadhim, I.J.; Ubaid, W.J., 2021, *Perception of Architectural Output: The Presence of Architecture in The Presence of a Pandemic*. [in] IOP Conf. Series: *Mater. Sci. Eng.*, *1067*, 012025.  
 [12] WHO., 2018, *Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World*; World Health Organization. Geneva, Switzerland.  
 [13] Engelen, L., 2020, *Does Active Design Influence Activity, Sitting, Wellbeing and Productivity in the Workplace? A Systematic Review*. *Int. J. Environ. Res. Public Health MDPI*, *17*, 9228.  
 [14] Peters, T.; Halleran, A., 2020, *How our homes impact our health: Using a COVID-19 informed approach to examine urban apartment housing Archnet-IJAR*. [in] *Int. J. Archit. Res.*, *15*, 10–27  
 [15] Priday, C., 2020, *Architecture after coronavirus*, Available online: <https://exepose.com/2020/> (accessed on 3 July 2021)  
 [16] Belzunegui-Eraso, A.; Erro-Garcés, A., 2020, *Teleworking in the context of the Covid-19 crisis*. [in] *Sustainability*, *12*, 3662. doi:10.3390/su12093662.  
 [17] Marr, B., 2020, *How the COVID-19 Pandemic is Fast-Tracking Digital Transformation in Companies*. Available online: <https://www.forbes.com/sites/bernardmarr/2020/03/17/> (accessed on 15 July 2021)  
 [18] Toffler, A., 1970, *Future Shock*; Bantam Books: New York, NY, USA  
 [19] Frumkin, H., 2021, *Environmental Health Perspectives*; John Wiley & Sons: Hoboken, NJ, USA.  
 [20] Petersen, A.H., 2020, *Are you sure you want to go back to the office? The future of work is flexibility*. [in] *New York Times*, 23 December 2020.  
 [21] PwC 2020. *When Everyone Can Work from Home, What's the Office for?*; PwC's US Remote Work Survey; PwC: London, UK, 12 January 2021. Available online: <https://www.pwc.com/us/en/library/covid-19/us-remote-work-survey.html> (accessed on 11 July 2021).  
 [22] PwC 2021. *It's Time to Reimagine Where and How Work Will Get Done*. *PwC's US Remote Work Survey*—January 12, 2021. Available online: <https://www.pwc.com/us/en/library/covid-19/us-remote-work-survey.html> (accessed on 20 September 2021).  
 [23] Wakabayashi, D., 2020, *Google delays return to office and eyes 'flexible work week'*. [in] *New York Times*, 14 December 2020. Available online: <https://www.nytimes.com/2020/12/14/technology/google-delays-return-to-office-and-eyes-flexible-work-week.html> (accessed on 11 July 2021).  
 [24] Capolongo, S.; Rebecchi, A.; Buffoli, M.; Appoloni, L.; Signorelli, C.; Fara, G.M.; D'Alessandro, D., 2020, *COVID-19 and Cities: from*

*Urban Health strategies to the pandemic challenge. A Decalogue of Public Health opportunities.*[in] *Acta Biomed*, 91, 13–22, <https://doi.org/10.23750/ABM.V91I2.9615>

[25] Tompkins, S., 2020, *4 Priorities for a Better Built Environment in the Post-COVID City*. 2020 World Economic Forum. 18 December 2020. Available online: <https://www.weforum.org/agenda/2020/12/4-priorities-better-built-environment-cities/>(accessed on 11 July 2021).

[26] Alter, L., 2020, *Architecture after the Coronavirus*. Available online: <https://www.treehugger.com/green-architecture/architecture-after-coronavirus.html> (accessed on 15 April 2020).

[27] Bonenberg, A., Lucchini M., 2021, *Home Office Spaces for Smart Work. Impact of Covid-19 Lockdown on Arrangements of Residential Interiors* [in] *Space & Form* - 2021, nr 48, s. 9-30

[28] Hossam, N., Zaher, E., 2020, *Design Solutions for Interior Architecture Post Coronavirus (COVID-19)*. [in] *J. Arts Archit. Res. Stud.*, 1, 117–133.

[29] McKeown, 2008, *C. Office Ergonomics: Practical Applications*; CNC Taylor and Francis: London, UK.

[30] Biggs, M.; Büchler, D., 2008, *Eight criteria for practice-based research in the creative and cultural industries*. [in] *Art Des. Commun. High. Educ.*, 7, 5–18, <https://doi.org/10.1386/adch.7.1.5.1>.

[31] Habraken, N.J., 1998, *The Structure of the Ordinary*; MIT Press: Cambridge, UK; London, UK.

[32] Nascimento, D.M., 2012, *Habraken explains the potential of the Open Building approach in architectural practice*. [in] *Open House Int.*, 37, 5–13, doi:10.1108/OHI-04-2012-B0001].

[33] Bonenberg, A., 2018, *Cityscape in the Era of Information and Telecommunication Technologies*; Springer: Cham, Switzerland.

[34] Fox, M.; Kemp, M., 2009, *Interactive Architecture*; Princeton Architectural Press: New York, NY, USA.

[35] Kronenburg, R., 2007, *Flexible Architecture that Responds to Change*; Laurence King Publishing: London, UK.

[36] Volner, I.; Johnson, P., 2020, *A Visual Biography*; Phaidon: New York, NY, USA.

[37] Nebois, T. (Ed.), 2003, *Architectural Theory from the Renaissance to the Present*; Taschen: Cologne, Germany; Volume 2, p. 680.

[38] Habraken, N.J., Mignucci, A., 2009, *Supports: Housing and City, Essays on Supports, Thematic Design and architectural education as part of the Laboratorio de Vivienda del Siglo XXI at ETSAB Barcelona School of Architecture*. [in] *Introduction by Josep Maria Montaner and Zaida Muxí*; Universitat Politècnica de Catalunya-BarcelonaTECH: Barcelona, Spain.

#### ONLINE SOURCES

[1] Google Scholar Search Results. Available online: <https://scholar.google.com/> (accessed on 3 July 2021)

[2] YouGov: <https://yougov.co.uk/topics/economy/articles-reports/2020/09/22/most-workers-want-work-home-after-covid-19> (accessed 15.11.2021)

[3] <https://www.archdaily.com/936064/is-coronavirus-pandemic-accelerating-the-digitalization-and-automation-of-cities> (accessed on 25 April 2020).

[4] Analisi dell Costruito, Comune di Genova, 2011. [http://puc.comune.genova.it/03\\_11\\_2014/DEF/1\\_DF/1\\_10\\_doc.pdf](http://puc.comune.genova.it/03_11_2014/DEF/1_DF/1_10_doc.pdf), (accessed on 23 July 2021)

#### UNPUBLISHED MATERIALS

Opracowania projektowe wykonane na Wydziale Architektury Politechniki Poznańskiej, w ramach przedmiotu Pracownia Badawcza, kierunek Architektura, autorzy: M. Śliwiński A. Poniży, M. Flak pod kierunkiem A. Bonenberg; projekty koncepcyjne i wizualizacje.