Smart dwellings.
Architectural perspectives opened by COVID-19 pandemic

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Abstract
Preamble: The pandemic with COVID-19 that we have been experiencing globally for almost one year now brings continuous challenges on many levels, the built environment being an important one. Social distancing meant that during this period housing has been requested differently, first as a shelter, now as a space in which we have to work or learn.
Objectives: The research aims to identify dwellings parameters that need reconsideration from the pandemic experience with COVID-19, how these can be adjusted in order to meet safety and comfort requirements to ultimately maintain well-being.
Prior work: The paper investigates the latest written documents on the influence of the pandemic with COVID-19 on the built environment, including published articles, peer-reviewed articles, digital blog posts, expert opinions.
Approach: The research is of narrative review type and interdisciplinary investigation of the specialized literature but at the same time it is also a reflection of the personal experience of the authors during COVID-19 pandemic. The following parameters of the home are analyzed: areas, dimensions, functions, finishes, accesses, lighting, relationship with the outdoor.
Results: Health, safety and comfort are 3 aspects that were tested during the quarantine period and are essential when we talk about housing and pandemic dwellings. It is estimated that there will be changes in the design of new residential buildings, collective and individual. Homes will need versatility, more generous spaces, functional expansions so as to cover both living and work or learning areas. There is talk of a living architecture but at the same time of touchless technology. The post-pandemic COVID-19 architecture will emphasize the user's well-being, but with much more emphasis on safety issues.
Implications: The challenges of the pandemic will influence the design process with possible changes in regulations, with an impact on architects, verification requirements, and contractors but also costs for the beneficiary. The architecture of post-pandemic housing will be an interdisciplinary collaboration between architect and specialists such as medical doctor, biologist, psychologist, engineers.
Value: The paper highlights the importance of the need for an interdisciplinary approach in the design of housing, a new aspect catalyzed by the pandemic with COVID-19.

Keywords: COVID-19 pandemic, architecture, dwelling, social distancing, interdisciplinarity.

1. Preamble
The pandemic with COVID-19 that we have been experiencing globally for almost one year now brings continuous challenges on many levels, the built environment being an

important one. From the beginning of 2020 until the time of writing this article globally, there are almost 89 million confirmed cases of SARS-CoV- 2 infection, including almost 2 million deaths reported by the WHO [1]. If we talk about the total number of cases, the first 3 places are occupied by the United States, India and Brazil. The ranking when we talk about the number of cases reported per million inhabitants differs; the first three places are occupied by Andorra, Gibraltar and Montenegro, the United States here occupying only the 8th place [1]. Romania is approaching 700,000 cases of SARS-CoV-2 infection and 17,000 deaths so far [2].

This article in its full-text version is written at the time when several COVID-19 vaccines were approved and started to be used, it is a moment of regaining hope, a moment in which we look again to deal with a normal life. We come out with this paper as a detailed research of a presentation made in early December last year (2020) at the Smart Cities conference, but things are changing very quickly, at this time (January, 2021) the approval of several vaccines and their use is a decisive factor to get our lives back.

The effects of the pandemic with COVID-19 are felt on several levels, not only that of public health, we are talking also about the dramatic reduction of economic activities, about important social and psychological effects [3].

Social distancing has meant that during this period housing has been requested differently, first as a shelter, then as a place in which we have to work or learn: **shelter in place, work in place and learn in place**. We are writing at an important time when we think that by the middle of 2021 we will slowly return to normal life, we will come back to the offices and the children will take classes in schools again. At this moment, however, the home must still respond to the same requests in addition to the way it is designed, telework, teleschool, telemedicine, active and passive recreation, socialization.

The built environment, the architecture of the medical but also of the residential buildings was extremely demanded during this period and it will still continue to remain so until the results that the vaccination, respectively the mass immunization will give. The open space office buildings also had demands, some of them became empty, opting for safety reasons for working from home. The interaction spaces remained empty, as well as the public spaces, the buildings of the theaters, the cinemas, the restaurants [4,5] seeing here the limits that architecture can have in case of a pandemic.

2. Objectives

The present research aims to identify dwellings parameters that need reconsideration from the pandemic experience with COVID-19, how these can be adjusted in order to meet safety and comfort requirements to ultimately maintain well-being. The directions pursued in this research converge towards a dwelling architecture that supports health and safety, which offers a new approach of the 21st century, different from the one from the XIV-XX centuries in which the form followed the fear of infection [6]. We propose an interdisciplinary approach that considers multiple layers of protection.

3. Prior work

The paper investigates the latest written documents on the influence of the pandemic with COVID-19 on the built environment, including published articles, peer-reviewed articles, digital blog posts, expert opinions.

Looking back in history, especially in the last 2 centuries, pandemics have always had an impact on architecture, urbanism and interior design. Before these, between the 14th and 18th centuries, also the plague killed millions of people in Europe, the Romanian territory being no exception, in Timisoara and Arad there are monuments of gratitude dedicated to the Holy Trinity for those who survived the plague (pandemic of 1730-1740). [7]

The infections brought new demands to which the architecture had to respond related to health, hygiene, comfort. [6] The challenges have pushed architecture to evolve both in terms of spatiality and in terms of materials and technology.

An important example is the Modernist architecture of the early XXth century that grew also from the lessons learned from the Spanish flu and cholera pandemics. [8]

Throughout the XIXth century there were 6 cholera pandemics that killed hundreds of thousands of lives [9]. Cholera wreaked havoc in Romania in 1913, especially in the army, along with other diseases such as typhoid fever, recurrent fever, epidemic jaundice, smallpox [10]. Modern Romania is, to a large extent, the result of cholera and the crisis of the European quarantine system [11]. Also in the early XIXth century, 1810-1815 tuberculosis aggravated by overcrowding cities was the cause for more than 25% of deaths in New York City [12,13]. Tuberculosis has triggered perhaps the most significant relationship between a disease and the built and natural environment. In Europe and United States the Sanatorium Movement started once with Koch's discovery in 1882 of the bacillus that bears his name. [14]

"Hygiene and moral health depend on the lay-out of cities. Without hygiene and moral health, the social cell becomes atrophied." (Le Corbusier, 1929, *The City of Tomorrow and Its Planning*) [15]

Perhaps Modernist Architecture is one of the most eloquent examples for the input given by the pandemics to the built environment. Modernist Architecture is characterized by simple forms, clean volumes, by giving up ornaments. Modernist Architectures is of course part of the movement of refreshment and exit from the canons of classicism, the release of precepts but clearly other connections can be made and an important one is through the hygienic perspective. At the beginning of the twentieth century, design was seen until the 1940s when the treatment of tuberculosis was discovered, a kind of universal panacea for crowded cities, there was talk of Clinical Environments [16].

The current pandemic with COVID-19 and its relationship with the built environment began immediately, when the lockdown was declared worldwide. There are articles that discuss the problem of the built environment, of architecture in general, how architecture can contribute to maintaining the health of the population, to provide safety and comfort.

Various post-pandemic design competitions were organized for the redesign of public spaces, consumption spaces (restaurants, bars, cafes), office spaces, dwellings, interior spaces in airplanes for safer travel such as: *Pandemic Dwelling- Home in times of Pandemic design contest* (17th May 2020-30th August 2020) [17]. These competitions have generated new ideas about the architecture of a post-pandemic world, targeting the year 2025 [18], of which we mention: reusing empty office space to house the homeless, community retrofit by design, cutting road traffic on domestic streets and changing the culture of car driving, converting existing shops into homes that still function as a point of exchange – with spaces for meeting and entertaining, agroecological approach to land use and a green innovation network, creating new spaces between private home and public social space, prefabricated extensions expand homes, shared streets' with cleaner, greener, safer environments, new rural models to revive denuded villages.

Of course, the space as it is designed can contribute to the observance of the established minimum distances, it can prevent congestion. The use of certain materials with antiviral and antibacterial properties is also discussed. Open space in office buildings is being questioned at the moment and new answers are being tried.

If we talk about housing, during this period it was perhaps the most requested, each of us noticed its limits to the activities we had to carry out inside it. If the trend in recent years has been the opposite, towards decentralization of non-residential activities just to keep the house as close as possible to what it means a home-peace, relaxation, family-in this period of pandemic the opposite happened. We have practically witnessed a forced centralization of all our activities towards the home, which has become too small, too crowded, too requested.

4. Approach

The research is of narrative review type and interdisciplinary investigation of the scientific literature but at the same time it is also a reflection of the personal experience of the authors. The following parameters of the home are analyzed: areas, dimensions, functions, finishes, accesses, lighting and relationship with the outdoor.

Delimitation of the research field: In this study we refer when we talk about homes, especially those of the apartment type in collective buildings and we focus on Romania urban areas.

 "[…] home is fundamental to being human" [19]

One of the most appropriate perspectives from which we can talk about housing is the phenomenological one, from this point of view we can refer to the home as that PLACE in which we retire, in which we are together with our loved ones, which charges and recharges us again and again.

"Home is that place that everyone feels it's his, is that place he creates and recreates based on his own needs, desires, values, ambitions." [20]

Of course the way of living differs from each person, from each family, the requirements are different [20] depending on several parameters of the user.

In a period of pandemic such as the one we are experiencing, we found that there were additional needs for use related to our homes.

Aigbavboa & Thwala adapt the Maslow's pyramid of needs to dwelling needs; we highlight from this study the levels that became important in this pandemic such as: psychological needs, safety and social needs [21].

A comprehensive analysis of the current situation emphasize new user' needs the dwelling must respond to, nowadays, imposed by this pandemic, arising from this physical and social distance: safety (repeated disinfection of purchased products and household surfaces), home-work (primarily developed technology, internet, a space to have peace, confidentiality, efficiency), home-school (IT technology and a dedicated space), socializing (again internet), telemedicine (internet), home sports (space that allows physical activities so neighbors are not disturbed by noise). Starting from these new needs for which our house needed adaptations during this period, the following parameters of the home are analyzed: areas & dimensions, functions, finishes, accesses, lighting, relationship with the outdoor with focus on limits of the present.

We would call it physical distancing, although we are talking about social distancing, it could not have been possible if we did not have a place to retire.
"Without a home, there can be no social distancing." [19]

4.1. Dwelling parameters
4.1.1. Areas & dimensions
1. too small areas;
2. small number of rooms;
3. mostly apartments, designed for housing strictly needs / bedroom neighborhoods.

Currently in Romania the minimum useful areas for residential apartments are established by the Dwelling Law no. 114/1996 - updated 2019 [22]. It is interesting that, according to this law, minimum usable areas are specified both depending on the number of rooms and depending on the number of users. For example, for a 3-rooms apartment there are 2 hypostases, with 3 and 4 users: for a family with 3 members, a 3-rooms apartment should have at least 66sqm while for a family with 4 members the usable area increases at least 74sqm. In reality, this number of users cannot be imposed by law, in Romania families of 5 members can live in 2-rooms apartments, probably also reminiscent of the dormitory neighborhoods built during the communist period, which constitute the majority housing stock in Bucharest, the capital of Romania [23]. So taking the minimum usable area of 66sqm for a 3-rooms apartment (characteristic for example of collective housing built in the 60s) notice that in the case of this pandemic was often too small. The minimum surface

of 22sqm allocated by law for 2 bedrooms can be enough just to rest, you can no longer offer the position of working or learning from home in comfortable conditions.

4.1.2. Functions
- small number of rooms- insufficient capacity for activities other than housing;
- OPEN SPACE-lack of privacy, confidentiality;
- PARTITIONED SPACE-slightly versatile;
- lack of storage space;
- the need for disinfection and cleaning spaces;
- need of working space/office space;
- need of learning space.

As we discussed in the previous point, the relationship between the number of rooms, areas and the number of users is only indicative by the Law of Housing [24]. Often in Romania, all the rooms of an apartment are used for sleeping, including the so-called living room. And then can we work from home? The "third room" is not a free room, an office. Another situation is the newly built apartments that rely on the so-called maximization of the usable area by minimizing the partitions. Here most of the times the dedicated partitioned storage spaces have completely disappeared, there is no pantry, closet although, attention, the Housing Law in force provides these surfaces which for a room apartment should have between 2.5sqm and 3.5sqm, small areas, insufficient for the lockdown period during the pandemic when we had to shop as rarely as possible.

Of course, if we refer to the advantages of an open space, we find a greater flexibility in use through various possibilities of reconfiguring the furniture. But what do we do with acoustic comfort, with the need for intimacy, confidentiality when we work from home and at the same time the children have school from home.

4.1.3. Finishes
- finishes not resistant to repeated disinfection.

The SARS-CoV-2 virus can be contagious, even from contact with surfaces, so the recommendation was to repeatedly disinfect frequently touched surfaces such as doors handles, switches, floors, especially at the entrance [25]. These disinfectants such those based on chlorine recommended as effective often attack the finishes [26].

4.1.4. Accesses
- for new apartments - non-existence of a separate access hall, useful for disinfection, for separating clothes from outside.

From this point of view, the apartments built before '89 proved to be more useful during the pandemic due to the existence of separate halls from the living room [27].
The new apartments, however, most of the time no longer have this separate entrance hall, there are no more separation doors between the living room and the access, making it difficult to separate the clothes and shoes from the outside.

4.1.5. Lighting

- the need for increased natural light-therapeutic effect, many apartments insufficiently lit for work or learning activities.

Lighting is one of the most important aspects when it comes to health and well-being, efficiency at work or learning. The most important is that natural light fights depression, anxiety [28,29], activates us and give a good vibe. In this sense, contemporary office buildings have almost entirely glass facades, in the same way, in educational buildings there is a tendency towards a maximization of glazed surfaces. Dwellings have a different degree of glazing, more weighted sometimes insufficient. This lighting issue combined with the need to improvise furniture for activities other than those intended for housing proved to be some shortcomings in the pandemic. Natural light has also therapeutic effects, in terms of biostimulation of human body functions, as well as in terms of germ reduction [30].

4.1.6. Relationship with the outdoor

- balconies or terraces too small for outdoor activities.

Disconnections of nature, lack of outdoor activity or sun exposure were some of the problems we faced during this pandemic. Keeping connected with the nature is essential in order to avoid depression and anxiety [31]. The balconies, the loggias, the terraces for those who live in the block of flats were most of the times the contact valves with the outside, the place where we could breath fresh air without a mask, without the fear of sickness. It was found during this period that the areas of these balconies, terraces were insufficient to accommodate such roles. The blocks built in the 60's have narrow, long balconies, 1.10m wide, the blocks built in the 70's start to have more generous, wider balconies, in the 80's the balconies shrink in size although the usable interior area of the apartments increases. Currently, the newly built collective residential buildings tend to offer more generous terraces with more pleasant proportions, their depth increases, offering the possibility to carry out various activities [32]- dining, relaxation, possibly sports activities. Those who live in villa-type houses have benefited from access to their own yard.

4.2. Experts' opinions

From the beginning, the approach was declared as being an interdisciplinary one, the opinions of 3 specialists, psychologist, physician and biologist (co-authors of this paper) were requested by the architect in 2 moments of the research, both at the beginning to identify the problems that faced people in this pandemic period as well as at the end, in the implications section.

4.2.1. Psychologist' opinion

The restrictions imposed in quarantine situations are extremely unpleasant for those who suffer from it. Separation from loved ones, travel restrictions, job and illness uncertainty or access to health services arouse feelings of loss of freedom and have dramatic effects on people's lives, on their ability to perform their usual and professional activities or be able to overcome this situation.

- Negative psychological effects [33]:
  - symptoms of acute stress disorder;
  - confusion, exhaustion, detachment, insomnia;
  - poor concentration and indecisiveness;
  - work performance deterioration;
  - frustration, irritability, substantial anger generated;
  - anxiety related with febrile patients;
  - suicide has been reported.
- What we need?
  - proper information - people who are quarantined need to understand the situation;
  - effective and rapid communication [34];
  - proper environment to support the isolation in terms on minimal psychological disturbances;
- Most of the adverse effects come from the imposition of a restriction of liberty [35]. Voluntary quarantine is associated with less distress and fewer long-term complications, public health officials should emphasize the altruistic choice of self-isolating, if possible.

4.2.2. Physician' opinion

Pandemic is a complex phenomenon of biological nature with multiple implications for individual health and public health, personal life, communities and society. Focusing on health-related aspects of architecture during pandemic times, we must stress out:

- Infection prevention necessity;
- Physical distancing necessity to prevent the spread of infection [36];
- Physical activity necessities in home or near spaces, especially for elderly patients, for whom sedentarism is a negative factor for health and a predictor for mortality and various co-morbidities [37];
- Medical care at home, to avoid patients contact with health services in which the possibility to be infected is increased during pandemics [38];
- Home as a working space – labor medicine considerations (lightning, smell, phonic insulation, schedule organization etc.);
- Communication necessity – a basic need of human beings;
- Mental health: stress, burnout prevention, social interaction [33];
- Home as a "mini-life mall" -anthropological perspective; although health related needs are the starting point to address pandemics one does not have to stop the analysis to an one-dimensional biomedical approach. One of the pillars of public health response to pandemics is social distancing, which restricts and contracts the physical and social area to home area. Hence home has to become a mini-life mall by concentrating various aspects of individual and social life, in order to fulfill all human needs.

4.2.3. Biologist' opinion

- Confinement (alone or with others)- a stressor & a behavior changer for any living being (for rodents and human astronauts alike) [39];
- Social isolation [40] changes values and motivation for activities;
- "Media stress" [41] changes cortisol-based hormones level;
- Stress of forced contact and use of new technologies [42] for work vs. lack of employment, lack of social protection [43];
- Restrictive measures may increase awareness and bring new jokes, but also increase aggressivity [44] and self-oriented behavior in some;
- Perception is altered [45] and everything becomes a source of danger and distress.

5. Results

Health, safety and comfort are 3 aspects that were tested during the quarantine period and are essential when we talk about housing and pandemic dwellings. It is estimated that there will be changes in the design of new homes, collective and individual. Homes will need versatility, more generous spaces, functional expansions so as to cover both living areas and work or learning areas.

What homes will be sought in the near future?

Although we are heading for a normal life with vaccines validation and the hope of mass immunization, the COVID-19 pandemic will bring about changes in the way we design housing. The pandemic will continue and our comfort is essential when it comes to dwelling. Likewise, the productivity of work from home must be sustained. This pandemic has generated new living, teleworking, telelearning behaviors that will surely be maintained even after it passes. The liberal professions will certainly continue at least partially to take place at home.

"For some families, [it] might mean multiple adults need work space." (Dwayne MacEwen cited by Jeffrey Steele) [46]

Expansion of living space in relation to new needs, new behaviors and new dwelling scenarios should be correlated with the increase of minimum areas in the Housing Law. This increase of the usable area will generate both open space and compartmentalized spaces or with the possibility of partition [47]. Of course these aspects will bring additional costs for those who will buy new apartments but this aspect should be managed by developers probably by slightly lowering house prices. Somehow this pandemic is a time from which the comfort of future homes can increase [48] and, thus, the condition for the good of users. We are practically heading for a rethinking of luxury.

There is talk of a living architecture [8] but at the same time of touchless technology [49]. The post-pandemic COVID-19 architecture will emphasize the user's well-being, but with much more emphasis on safety issues.

After an analysis of the most relevant documents written during this period about housing design in a post-pandemic world, we synthesized interdisciplinary (architecture-medicine-psychology-biology) 11 points that should be considered for the design of new collective housing buildings [50].

5.1. Dirty / clean separation chamber

This period of pandemic taught us that we must pay attention to decontamination when we get home from outdoor space, respectively an open-space type did not work well during this period. In this sense, it is recommended to return to a hall with the possibility of closing, a clean break between the outside world and domicile that can provide enough space to store in an elegant, comfortable way jackets, scarves, gloves, shoes and disinfectants.

5.2. Hands-free entry

In this pandemic, the lesson we learned was to avoid contact with frequently touched surfaces such as handles, elevator buttons. It is recommended that touchless technologies to be included primarily in the design of entrances to residential buildings. They can be considered also automatic latches, foot-operated openers, freedom of hands are also important when we come home, for example, full of shopping.

5.3. Large kitchen, bathroom, dryer / large capacity appliances

It turned out during this period of pandemic that we needed to store food, to disinfect what we were buying, that the kitchens and bathrooms turned out to be too small and that more appliances would have been needed. In Romania, the minimum areas according to the current Housing Law are extremely small for kitchens, respectively between 5.00sqm (studio, 2-room apartments) and 6.5sqm (5-room apartments) [22]. These areas are recommended to be enlarged so that kitchens can accommodate larger refrigerators and freezers, a dishwasher with a large capacity will save time and water. Also, during this period, the restaurants being closed, more cooking was done at home, these acquired behaviors that can work in the future, it is recommended more generous areas to unpack groceries, for washing vegetables and fruits, for preparing meat dishes. The trend at this moment in Romania is that in kitchens, due to the small space, the space is used a lot vertically. If we are talking about the elderly, their comfort and safety depends precisely on the of space horizontally, to avoid falls that may result from climbing to access high storage spaces. Increasing the surface of the bathrooms is just as important to be able to include appliances such as a washing machine or bidet. A big problem is the drying of the laundry and, although it seems a luxury, it is proposed to design the apartments with their own dryers. During this period we washed and disinfected more often both clothes and products.

5.4. Large pantries

In Romania, the new apartments have almost non-existent storage spaces, according to the Housing Law in force, they vary between 2.00sqm (studio) and 5.00sqm (5-room apartment) [22], in reality they often do not exist. This pandemic showed that the apartments built before the 89s that have a pantry, closet, storage room worked better. It is important that future apartments are designed having extra storage space for dry goods, paper products and disinfectants.

5.5. Dedicated workspace

Working from home was one of the biggest challenges of this period. Working from home means first of all the need for space, then for quiet, for confidentiality. There should be an extra room that is not a bedroom, a multifunctional room with multiple uses in which to work, to have virtual meetups, to do home education or sometimes have sports. There is a need for a separate room large enough to accommodate such activities or if we are talking about an open space living room to provide the flexible possibility of partition when needed.

5.6. Extra wall insulation

The multifunctionality to which the homes were requested also meant a higher noise both between the rooms of the same apartment and between different apartments. New additional extra soundproofing requirements appear to ensure the necessary comfort.

5.7. Generous terraces

Private terraces, loggias, generous balconies become a must for future residential buildings. It is very important that their depth to be more generous, over 1.8oml to be able to be furnished for various recreational activities. If the area is still small, a close ratio between length and depth should be sought, preferably to a long and narrow balcony. Larger terraces can even accommodate study areas or outdoor work, dining or sports activities, small vertical gardens, even vegetable gardens.

5.8. Flexible spaces / Flexible furniture

The flexibility of space of the future residential buildings not only in a post-pandemic world is essential to keep up with the new challenges of society, with a lifestyle always changing. Spatial flexibility is one of the strengths of modern housing. We are talking here about the structure of these buildings which is recommended to be on frames and not diaphragms so that the partitions of these apartments to be light, nonstructural.

The COVID-19 pandemic that we are still experiencing proved to us the need for closed, partitioned spaces in order to have privacy, silence, and confidentiality. At the same time, there is a need for open spaces, communicating when other activities than residential have ended, the relaxation areas to be as generous as is possible. So we are talking about two types of multifunctionality - by merging-concomitant but also by flexibility, versatility so that the area-quality-price ratio to be optimal [51].

In support of a flexible, multifunctional space comes adaptable, versatile, modular furniture that allows various uses. Although the surface of the apartments seems impetuously necessary to increase, we are not talking about individual homes, the space will always be limited and then the versatility of the furniture will always be a plus.

5.9. Smart dwelling/ high technology included

It turned out during this period that communication technologies, the Internet were the support of all our activities, teleworking, teleschooling, socializing, maintaining connections with loved ones.

In addition to communication technology, a smart home means safety and comfort for the elderly and people with disabilities, people with neurocognitive disorders - accessibility, Universal Design, assistive devices [52]. Besides the architectural tools available-light, shape, color, texture, sound- technology brings new possibilities to increase comfort such as-lighting control, the possibility of telemedicine, even remote cognitive stimulation and immersive virtual environments [53]. Innovative systems for integrating architecture with technology must be researched specifically for housing.

5.10. Antimicrobial fabrics and materials, easy-to-clean textiles

Tomorrow's homes could have furniture with antimicrobial fabrics and materials and be easy to clean.

Homes will need versatility, more generous spaces, functional expansions so as to cover both living areas and work or learning areas. There is talk of a living architecture but at the same time of touchless technology. The post-pandemic COVID-19 architecture will emphasize the user's well-being, but with much more emphasis on safety issues and on self sustainable homes [54].

6. Implications

The implications of the COVID-19 pandemic are on several levels, both at the societal and individual level and require from our point of view an interdisciplinary approach. We are talking about public health but also about the physical and mental health of each individual, about economy and safety. Architecture must take into account all these aspects. In order to have a correct position in the design of housing in a post-pandemic world, we considered in this research the opinions of 3 specialists, psychologist, doctor, biologist integrated by the fourth expert, the architect.

6.1. Psychologist' opinion

The recovery after a long period of imposed isolation takes time and may not happen as we expect, especially during a pandemic with an unknown end. Awareness, balance and constant connection with the environment can help. Setting a daily set of goals, daily routine, finding new strategies to overcome the new situations, excessive worry or anxiety, fear or even boredom are necessary.

- Coping strategies:
  - providing opportunities to reduce feelings of social isolation during times of social distancing by encouraging non-work related virtual social connections [55];
  - care for your emotional health [56] - finding a balance between work and home is important, the use of good time management skills and priority setting can help you focus on something practical to do right now;
  - attend to your physical self-care – our personal environment [57] is extremely important, is where we need to find the perfect place to work, to study, to exercise for stress reduction, to relax and to take an adequate sleep;

- reduce and limit exposure to media coverage [58] of the pandemic – even though we need to be proper informed and we need to have access to all the news related with the subject, watching media coverage for long periods of time may actually increase anxiety, as this can keep our response systems activated;
- create a structure and routine [59] for the day – in this way you can foster a sense of control and bring predictability to this unpredictable situation, so this will help us to reduce stress responses and facilitate recovery.

6.2. Physician' opinion

Health measures should aim to prevent spread of infections, support physical activity and communication, in the mean time being culturally appropriate, non-intrusive and supporting individual values. We propose the following solutions:

- Smart infection resistant materials [36];
- Smart technologies for disinfection;
- Transformable home spaces through technology (e.g. for leisure activities, fitness, work environment);
- Availability of telemedicine services [60];
- Availability of services for stress prevention and management [33];
- Medical sensors (heart rate, temperature, activity etc.)
- New perspectives for virtual/augmented reality;
- ICT infrastructure and communication services ;
- GDPR and e-privacy standards compatibility;
- Smart Working Environment (lightning, smell, phonic isolation, schedule organization etc.);
- Individualized and culturally adequate environment changes.

6.3. Biologist' opinion

By nature and our species' history, human beings are born to be social, to build themselves from their relationships with the social environment, through trust and empathy. Social isolation and a constant uncertainty of present, future, values and personal status in the society means distress and disability. We can counteract with specific actions, at individual and societal level.

- For individual:
  - You need to change your perspective [61];
  - If we cannot go outside, bring nature [62] inside;
  - Get a pet [63] and grow a lot of happy plants [64] (for eyes, color and aromatherapy as well as for air cleansing and ionizing), bring wood and natural stone inside, use curves for interior design and earth bright colors for finishing;
  - Stay physically active [65] and surround yourself with music and nature sounds [66] – improves mood, cognition and physical health (in this order);
  - Use your time to learn new things, how to use ICT technology but also here-and-now (zen) meditation [67].
- For society:
  - keep in touch with your work team and family [68] and also make new friends;

- be happy & grateful for each second with yourself and your beloved ones; don't forget kids [69] are most exposed to this new situation;
- Understand the world [70] is not (only) about you;
- Rethink urban common spaces [71] as well as residential spaces (larger, with more light and with decompression spaces, easy to disinfect and manage);
- Air & light are essential for a good health, but also so are free space roaming and social meetings, challenges, concurrency and teaming;
- Use water, air, stone and trees for common spaces;
- Implement new self-disinfecting materials.

The challenges of the pandemic will influence the design process with possible changes in regulations, with an impact on architects, verification requirements, contractors but also costs for the beneficiary. The architecture of post-pandemic housing will be an interdisciplinary collaboration between architect and specialists such as medical doctor, biologist, psychologist, engineers.

7. Value
The paper highlights the importance of the need for an interdisciplinary approach in the design of housing, a new aspect catalyzed by the pandemic with COVID-19. From our point of view, the COVID-19 pandemic represents a milestone with a significant impact in the perspective on contemporary housing, with a greater impact on the relationship between safety and comfort. We also emphasize that this moment COVID-19 represents an important step for a better collaboration, integration between architecture, home design and intelligent technology at the substance level, by taking into account *ab initio* the way the technology will be integrated. A smart home takes into account the safety and comfort of a user with a diverse profile, including frail, people with disabilities or neurocognitive disorders. The pandemic with COVID-19 will have echoes in the design of housing both at the architectural object and neighborhood level, in the end smart dwelling involves live & age in place / community. The research highlights the need to reconsider the issues related to the minimum areas of housing provided by law at this time COVID-19. A truly smart city of 2020 is….pandemic-proof.

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