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Dwelling in times of COVID-19: An analysis on habitability and environmental factors of Spanish housing

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ABSTRACT

In the wake of the SARS-CoV-2 pandemic, promoted by the World Health Organization (WHO), governments urged people to stay at home. For this reason, practically all human activity took place inside the houses. The research question established if housing quality responded to people’s needs in the context of confinement. Specifically, the purpose was to taxonomize the dwelling stock occupied by confined households during the first COVID-19 wave in Spain, as well as to deepen in features and subjective perceptions on Indoor Environmental Quality (IEQ). As an exploratory study, an online questionnaire was disseminated in the Spring of 2020, obtaining 1,673 valid responses. A descriptive statistical analysis included sociodemographic, territorial and housing variables, related to indoor environmental quality, the availability of outdoor spaces, and the prospects for changes in. Also, a logistic regression established multivariate relations for the dependent variable “general dwelling satisfaction”. The results associated urban habitat, tenancy regime, higher incomes, and fewer cohabitants, with worse perceived IEQ, and lack of own outdoor space. Same variables showed relations with people’s desire for domestic changes. In conclusion, it is remarkable the determining role of housing design for dwellers’ satisfaction, especially in uncertain times like COVID-19 pandemic. This not only conditioned the different ways of inhabiting and occupying dwellings, but also the people’s capacity to face lockdown. The built environment, the habitat, and households’ circumstances also influenced. The latter did on people’s perception of their experience, and how they lived and expressed it. Additionally, resilient building design and renovation opportunities were identified.

1. Introduction

The outbreak caused by the SARS-CoV-2 coronavirus had a global impact [1,2]. After several months of increasing transmission in various countries from Asia to Europe and other continents, the World Health Organisation (WHO) decided to raise it to pandemic level [3]. Given the severity and fastness of expansion of the coronavirus around the world, the WHO itself promoted extreme public health measures to the extent of staying at home to prevent the spread of the new disease [4,5].

In the Spanish case, physical isolation was formalised through social confinement [6], which was decreed on 14 March 2020 through the State of Alarm [7]. This confinement implied remaining indoors at all times, except for so-called essential activities linked to the most basic subsistence needs, such as logistics or health care, for example. The population, institutions and organisations were urged to work remotely if different tasks allowed it [8,9], just as teaching was closed at all levels, also promoting online classes...
[8,10]. This interruption of all activity also had serious social and economic impacts, especially affecting the most disadvantaged groups [11,12]. For this reason, as soon as the health authorities deemed it appropriate, confinement was progressively eased, gradually allowing the population to resume certain activities, both work and personal promotion and leisure related, while maintaining other social preventive actions [13]. In total, the national State of Alarm period lasted from 14 March to 21 June 2020, although the de-escalation stages began in May [14]. Households therefore remained in the same physical domestic space throughout the day during this period, carrying out the usual household activities, but also engaging in other activities that would normally be located elsewhere or outside [15] or activities intensively to the home or to care [16]. This change in the location of human activity decongested cities in terms of mobility, pollution and energy consumption, [17–19], but, on the other hand, inevitably displaced it to the interior of the residential space [20,21].

Housing plays an important role in the health of the people who live in it, as recognised by the WHO in 2018 [22]. The conditions of the living space have a decisive influence on the quality of life of its inhabitants [23], as well as on their life expectancy, to the point of generating or worsening different pathologies. Likewise, epidemics throughout history have led to the implementation of constant improvements in urban planning, the built environment and architectural design towards healthier models [24]. In particular, aspects related to the habitability, comfort or Indoor Environmental Quality (IEQ) of the dwelling have a direct impact on the well-being of residents, including thermal comfort, indoor air quality, lighting (especially natural lighting), and noise insulation. Since people normally spend more than 90% of their time indoors, prolonged overexposure to unhealthy environments determines their state of health [25]. indoors, the concentration of pollutants can be such as five times higher than outdoors [26]. For the same reason, poor air quality is considered by the WHO as the tenth most preventable health risk [27]. Good indoor air quality, promoted by adequate ventilation of spaces, dilutes, or eliminates airborne pollutants and pathogens, replacing them with clean air [28,29]. In the case of COVID-19, ventilation and exposure time are key factors in the transmission of the virus [30,31]. Thermal comfort, in turn, consists of “a complex state of mind that expresses satisfaction with the thermal environment” [32], in such a way as to protect people from external meteorological changes related to cold or heat [32,33]. Visual comfort and, particularly, natural light make it possible to carry out everyday tasks in a pleasant way, affecting not only sensory perception but also biorhythms [28,34]. Similarly, acoustic comfort is also decisive [35], which, among other functions, protects against external noise, or acoustic pollution [36].

The immediate built environment and urban planning determine the conditions of habitability, comfort, and indoor environmental quality to a large extent. The dwelling may enjoy a more or less healthy environment, depending on the solar orientation, its location according to the prevailing winds, the surrounding capable volumes and roads, and the dimensions of the immediate outdoor spaces, for instance. Although other aspects also have an influence, those related to the construction time and quality (affecting applicable regulations) [37], the users’ behaviour, the household’s healthy habits, and the building maintenance and for its surroundings.

These characteristics of housing take on special significance in the face of the disruptive and extreme event experienced during the confinements due to the COVID-19 pandemic. Having good natural light, appropriate ventilation, or outdoor spaces such as terraces, balconies or patios conditioned not only our predisposition to be resilient and cope better with staying in the house, but also our physical, emotional and psychological well-being [38]. On the other hand, the way of coping with confinement differed significantly depending on whether it occurred in large cities, medium-sized cities, or in rural areas [39].

In this context of confinement, there are studies devoted to describe the housing quality (including spatial, functional and environmental terms) at an international and (less) at a national level (mostly regional ones) [40]. However, most of them were focused either on their description and relations with people’s behaviour and well-being, including mental [41,42] physical and emotional health [43]. Others highlighted a certain aspect of the stay-at-home, such as working from home [44,45], lifestyle [46], feeding habits [47], sleep [48,49] or physical activity [50], for instance. Also, a proportion of those studies dealt with the transmission of the virus indoors [51]. Though, a scarcity of studies merely focused on the housing design, adaptation and household’s satisfaction according to the specific needs and routines established in this period, was detected. It makes this study relevant, contributing to a better understanding of the space relations, requirements and expectations, related to the population who currently live in, referred to their preferences, and adaptations both implemented and desired in this regard, facing such a disruptive and extreme event.

Thus, the research question established if housing quality responded to people’s needs in the context of confinement. Specifically, the aim was to taxonomize the dwelling stock occupied by confined households during the first COVID-19 wave in Spain, as well as to deepen in features and subjective perceptions on indoor environmental quality. The purpose is to obtain a “picture” of the lived moment in such extreme situation of lockdown, and describe it in terms of needs and expectations on housing, and more specifically, IEQ factors, by their own users.

Understanding the specific needs at a disruptive time helps planning and decision-making in terms of strategies and contingency and relief plans in the face of possible similar future scenarios. In turn, knowing the needs in the face of an unknown extreme event allows for the development of new ways of inhabiting spaces, whether in the recovery of existing housing stock, or new discourses that generate more flexible, resilient, and affordable housing against future threats.

2. Materials and methods

The general objective of this study was to analyse the living conditions of Spanish households during COVID-19 confinement, which affect the well-being and health of its inhabitants. As specific objectives, the following were established: 1) Analyse the characteristics of the dwelling and households during confinement, according to the population area (urban, rural, intermediate); 2) Describe the typology of homes with outdoor space and its type, during confinement, and the associated factors (habitat, average income level per household in the municipality, and dwelling features). 3) Observe how these factors (habitat, average income level per
household in the municipality, and housing characteristics) were related to the indoor environmental quality of the dwelling itself (lighting, ventilation, thermal comfort and noise insulation) during confinement; 4) Explore the same factors (habitat, income level and housing characteristics) regarding to the expectation of change in dwellings during confinement; and finally 5) Define the causal relations among the dwelling satisfaction, and their different qualitative characteristics.

To carry out this analysis, an online questionnaire was developed and distributed nationwide during the spring 2020 lockdown. A descriptive statistical analysis of household and housing-related variables, and a multivariate model based on a logistic regression, were carried out.

2.1. Data collection

For this report we used the information provided by the participants in the "Study on social confinement (COVID-19), housing and habitability [COVID-HAB]", carried out between 30 April and 22 June 2020, during the social confinement produced by the COVID-19 pandemic.

The online digital data collection tool SurveyMonkey®, was used for this data collection, and a database was created with all the variables gathered through the online questionnaire.

2.2. Questionnaire design

The original quantitative questionnaire consisted of an online survey, with 58 questions, including numerical, categorical, and Likert-type responses with 5- or 7- category scales. From among the themes of confinement, and household and dwelling features, those questions related to socio-demographic data, as well as detailed aspects on housing design and habitability, such as those related to IQ, were included for this analysis.

The questionnaire was revised and approved by an Expert Group from the Spanish National Research Council, belonging to their Ethical Committee.

When spreading the questionnaire, a presentation of the entity and the research group was made, as well as the aim of the study, the current context of confinement and the interest for Science. Also, the rights of participants to decline their participation in any time, the implicit consent to participate (clicking to access to the questionnaire) and other ethical considerations were included.

So, the questionnaire design was included as an implicit characteristic in the context of confinement, to highlight the relevance to answer questions during this period. Indeed, the collecting period covered the first COVID-19 wave, coinciding with the social quarantine.

The questions were designed following different official sources, depending on the topic asked, such as National Statistics Institute [52] for sociodemographic ones, or the ASHRAE 55 Standard [32] for thermal comfort, standing out the condition to answer reflecting on this living moment. Other questions were designed taking into account the intended behaviour changes according to the whole household permanence indoors. However, this kind of questions was not included in this analysis, except for the variable “housing design dissatisfaction”, which is detailed below.

To validate the construct of this questionnaire, reliability, validity and sphericity tests were carried out. The validity of the construct was defined by Kaiser–Meyer–Olkin Measure (KMO) of Sampling Adequacy, which released a result of 0.703 (over 0.7 value). The obtained Bartlett’s Test of Sphericity, which must be ≤0.05, was $\Phi = 0.000$, so it was also correct. To test the index reliability, the Cronbach’s alpha was calculated, giving a value of 0.785 (>0.7). When any item was deleted, no single value modified the general value significantly. Thus, the questionnaire was considered as appropriate and consistent.

2.3. Selected variables

To carry out this analysis, 20 variables distributed in five categories were chosen, related to the household composition, the dwelling characteristics, and the preferences regarding changes or adaptations in it, according to the experience of the COVID-19 confinement.

First, socio-demographic/territorial variables were determined, such as habitat (urban, intermediate, and rural), and quartiles of the average income of the municipalities (1st quartile < 26,529€; 2nd quartile = 26,529–30,759€; 3rd quartile = 30,759–34,418€ and 4th quartile > 34,418€).

For the calculation of quartiles, municipalities with less than 500 inhabitants were excluded. Therefore, sample households in municipalities with these characteristics were treated as lost cases.

Secondly, housing conditions were defined, as follows: type of dwelling (detached single-family, semi-detached single-family, studio or loft and attic, intermediate floor, ground floor); number of rooms, including kitchen, bedrooms and rooms larger than 4 m² (≤3, 4 y ≥5); usable floor area (m²); occupancy density (m²/person); orientation (inwards/outwards/inwards-outwards); availability of outdoor space (yes/no); type of outdoor space (courtyard-garden-communal space/open terrace-balcony/closed terrace-gallery); occupancy regime of the dwelling (owned/rented); and expenses related to the dwelling, if owned (no/outstanding payments).

Thirdly, the category on the household features was established, whose variables were: number of persons in the household (one/two/three/four or more), cohabitation with children under 18 (yes/no), and with persons over 65 (yes/no).

Fourthly, the so-called environmental quality of the dwelling was established, whose variables assessed were: dwelling sunshine, which was a question with six response options, re-categorised into the following three: completely sunny/sunny at some time of day/shade. The variables lighting and noise insulation were originally measured on a five-item ordinal scale: 1) not at all adequate, 2) not very adequate, 3) adequate, 4) very adequate and 5) totally adequate. They were re-categorised into two options, joining the first two and the last three. The ventilation variable was also measured with a five-item ordinal scale: 1) very bad, 2) bad, 3) fair, 4) good and
very good. This was also re-categorised into two options, combining the first three and the last two. Regarding the thermal comfort, following the ASHRAE 55 standard, seven categories were originally included (cold/cool/slightly cool/neutral/slightly warm/warm/hot), but recoded in two: “not in comfort” (responses 1 to 3 and 5 to 7), and “in comfort”, according to the category 4, called “neutral”.

Moreover, respondents were asked to provide what were termed their “housing change/adaptation expectations” (variables about those changes users would like to make to their dwellings, either feasible or not). This question identified several categories, chosen as the most frequent: modification of outdoor space, thermal and acoustic insulation, lighting, size, storage space, interior layout, and changes to windows. Then, a dichotomous variable was created (satisfied = 0, dissatisfied = 1) to find out the home (dis)satisfaction degree, based on potential changes in essential dwelling characteristics that users would like to make.

2.4. Data analysis

A descriptive analysis stratified by population area (habitat) of the variables describing the housing conditions and the households’ characteristics was carried out. The relationship between these variables was explored by bivariate analysis using the Chi-square test. A descriptive analysis of the variables “housing quality” and “expectations of changes/adaptations in the dwelling” was performed, and a bivariate analysis of their relationship with the socio-demographic and housing conditions variables was performed also applying the Chi-square test. All contrast analyses were performed at a 95% confidence level (significance at p < 0.05).

To find out the multivariate relationship between general satisfaction with housing, its different specific characteristics, and the socioeconomic conditions of the cohabitants, a binary logistic regression was carried out, thus developing a model of causal relationship. Perceived general (dis)satisfaction of dwellers was defined as the dependent variable.

For the model, the dependent variable was constructed from housing-design dissatisfaction. This dummy variable took the value 1 if, among the 16 home improvement options originally proposed in the question, the participant chose one of the eight considered essential, related to the home design (and therefore difficult to modify). These eight categories called essential were: housing size, storage space, outdoor space, thermo-acoustic insulation, window quality, natural lighting, views to the outside, and facilities (water, electricity, etc.). The other eight categories, not considered essential or design-related, could be easily modified by the cohabitants, and therefore would not be considered a reason for dissatisfaction with the dwelling. These were: distribution of interior spaces, solar control devices, surface finish of walls, appliances, furniture, artificial lighting, heating installation and space for vegetation (biophilia). The event considered to build the binary logistic regression model was to know which aspects of the dwelling and the household were causally related to dissatisfaction with the domestic design.

3. Results

In this section, the results covered the housing and households’ features and perceptions in the context of the COVID-19 quarantine, as a “picture” of the moment experienced.

3.1. General description of the sample

In total, 1,673 households responded to the questionnaire. Of this sample, 99% of information was available for the stratification variable: the population area (habitat). Most of the households (73.4%) were located in urban areas, while 20% were in intermediate areas and only 6.6% belonged to rural ones. With regard to the average income level of the municipalities, four out of ten (41%) of the households studied were in the highest income quartile, 29.2% belonged to the 3rd quartile, 18.4% to the 2nd quartile, and 11.4% in the 1st quartile. This distribution differs in a statistically significant way according to population area (Table 1): households in intermediate (58%) and rural areas (28.2%) of the sample were in municipalities with lower incomes (1st quartile), while households in urban areas belonged to municipalities with higher incomes (88.1% in the 3rd quartile and 84% in the 4th quartile).

3.2. Housing characteristics and coexistence features

Table 1 shows the composition of the surveyed households and the characteristics of the dwellings according to population area (habitat). On average, 2.63 persons lived there (SD: 1.27; Range: 1–9). More than a quarter of the households (28.5%) had four or more people living together. In 36.1% of households lived children under 18 and in 14.6% of households there were people over 65. The number of persons in the dwellings was statistically significant, according to the habitat variable. Dwellings located in urban areas were associated with households with two persons, while intermediate and rural areas were linked to living with four or more.

The average floor area of dwellings was 103.8 m² (SD: 53.85; Range: 20–600), which an average of 52.1 m² per household (SD: 32.75; Range: 10–300). The distribution of usable floor area of the households differed statistically according to habitats. Households in urban areas were associated with having less usable floor space (42.4% between 60 and 90 m²), compared to intermediate and rural dwellings (31.8% and 16.7%). Living in rural areas was associated with having more space per person (more than 60 m²). More usable floor space was statistically significant with lower-income municipalities (28.8% of the 1st quartile vs. 19.0% of the 4th quartile).

The majority of households surveyed (76%) were multi-family. Half of them were mid-rise flats (54%), 13.2% were studios and penthouses, and 6%, ground floor or semi-basement flats. 17.8% were semi-detached houses, and 9% were detached houses, in the countryside or in the mountains. The type of housing is statistically significant, related to the habitat and the average income level of the municipality. Urban areas were associated with intermediate flats, whilst rural did with detached houses. Confinement with high income levels (3rd and 4th quartiles) was associated with living in intermediate flats (20.4% and 40.1%, respectively). Lower average income levels (1st quartile) were associated with semi-detached (40.1%) or detached (20.4%) single-family dwellings.
Table 1
Characteristics of households in the study by population area (habitat).

| Variable                              | Total** | Urban area | Intermediate area | Rural area | p*  |
|---------------------------------------|---------|------------|-------------------|------------|-----|
|                                       | N (% col) | N (% col) | N (% col)         | N (% col)  |     |
| **Average household income**          |          |            |                   |            |     |
| 1st quartile (lowest)                 | 181 (11.4) | 25 (2.1)  | 105 (33.9)        | 51 (50.0)  | <0.001 |
| 2nd quartile                          | 291 (18.4) | 193 (16.5) | 75 (24.2)         | 23 (22.5)  |     |
| 3rd quartile                          | 462 (29.2) | 407 (34.8) | 44 (14.2)         | 11 (30.8)  |     |
| 4th quartile (highest)                | 648 (41.0) | 545 (46.6) | 86 (27.7)         | 17 (16.7)  |     |
| **Persons in the household**          |          |            |                   |            |     |
| One                                   | 351 (22.8) | 272 (24.1) | 53 (17.8)         | 19 (19.6)  | 0.002 |
| Two                                   | 428 (27.8) | 329 (29.1) | 73 (24.5)         | 24 (24.7)  |     |
| Three                                 | 323 (21.0) | 239 (21.2) | 60 (20.1)         | 19 (19.6)  |     |
| Four or more                          | 439 (28.5) | 289 (25.6) | 112 (37.6)        | 35 (36.1)  |     |
| **Useable floor area**                |          |            |                   |            |     |
| <60m²                                  | 244 (16.0) | 200 (17.8) | 26 (8.9)          | 16 (16.7)  | <0.001 |
| 60-90m²                               | 589 (38.6) | 477 (42.4) | 93 (31.8)         | 16 (16.7)  |     |
| 91-120m²                              | 374 (24.5) | 271 (24.1) | 78 (26.7)         | 21 (21.9)  |     |
| >120m²                                | 320 (21.0) | 117 (15.7) | 95 (32.5)         | 43 (44.8)  |     |
| **Area per person**                   |          |            |                   |            |     |
| <30m²/person                           | 419 (27.6) | 327 (29.3) | 70 (24.1)         | 20 (20.8)  | 0.005 |
| 30-44m²/person                         | 390 (25.7) | 299 (26.8) | 69 (23.7)         | 20 (20.8)  |     |
| 45-59m²/person                         | 241(15.9)  | 178 (15.9) | 50 (17.2)         | 12 (12.5)  |     |
| >60m²/person                           | 466 (30.7) | 312 (28.0) | 102 (35.1)        | 44 (45.8)  |     |
| **Type of dwelling**                  |          |            |                   |            |     |
| Single-family detached                 | 138 (9.0)  | 53 (4.7)   | 44 (14.8)         | 38 (39.2)  | <0.001 |
| Single family semi-detached            | 274 (17.8) | 133 (11.8) | 105 (35.4)        | 33 (34.0)  |     |
| Studio or loft and attic               | 203 (13.2) | 153 (13.6) | 43 (14.5)         | 6 (6.2)    |     |
| Middle floor                           | 831 (54.0) | 716 (63.5) | 89 (30.0)         | 17 (17.5)  |     |
| Ground floor                           | 92 (6.0)   | 73 (6.5)   | 16 (5.4)          | 3 (3.1)    |     |
| **Number of rooms**                   |          |            |                   |            |     |
| ≤ 3 rooms                             | 330 (21.5) | 262 (23.2) | 45 (15.3)         | 18 (18.8)  | <0.001 |
| ≥ 4 rooms                             | 309 (20.1) | 248 (22.0) | 44 (14.9)         | 14 (14.6)  |     |
| ≥ 5 rooms                             | 895 (58.3) | 617 (54.7) | 206 (69.8)        | 64 (66.7)  |     |
| **Occupancy regime**                  |          |            |                   |            |     |
| Own                                   | 1136 (76.4) | 797 (73.1) | 240 (83.6)        | 83 (89.2)  | <0.001 |
| Rented                                | 350 (23.6) | 293 (26.9) | 47 (16.4)         | 14 (28.6)  |     |
| **Housing expenses**                  |          |            |                   |            |     |
| No or low outstanding payments        | 570 (39.3) | 397 (37.2) | 117 (41.9)        | 45 (51.1)  | 0.019 |
| With outstanding payments             | 880 (60.7) | 670 (62.8) | 162 (58.1)        | 43 (48.9)  |     |

* P-value for the chi-square test of the relationship between housing characteristics and population area. p < 0.05 implies a statistically significant relationship. **Total data from univariate analysis of variables.

Most households (58.3%) had five or more rooms, 20.1%, four, and 21.5%, three. Rooms per dwelling showed a statistically significant relation with habitat. Urban areas associated with three or four rooms; intermediate or rural areas, having five or more. Higher number of rooms were related to lower-income municipalities.

More than two thirds of the households surveyed (76%) during confinement were owned, and 24% rented. The distribution differed in a statistically significant way according to habitat and average income level. Owned dwellings were associated with rural-intermediate environments and with lower income levels (1st and 2nd quartile). Rented housing was associated with living in urban environments and in municipalities with higher income quartiles (3rd and 4th quartiles). Of the owner-occupied households, 39.3% had no or very low outstanding payments. Household composition and tenure status showed a statistically significant association. Households with three (22.2% owned vs. 15.8% rented), four, or more cohabitants related to owned homes (32.2% vs. 15.8% rented). Living alone or with a couple was associated with renting (35% and 25.8% owning vs. 33.5% and 19.8% owning, respectively).

3.3. Outdoor area availability and its characteristics

Table 2 shows the relations of dwellings to the immediate built environment and the availability and type of own outdoor space. Eight out of ten households surveyed (82.9%) were oriented outwards: to an avenue, wide street, green area, etc. 9.5% of the dwellings faced outwards and inwards, and only 7.6% faced an interior or neighbour’s courtyard. Two thirds of the surveyed households (64.4%) had some kind of outdoor open space during the confinement. Of these, 62% had a terrace open to the outside and/or a balcony, 28.5% had a patio, garden, plot, or communal space with right-to-use, and 9.6% an enclosed terrace or gallery.

The immediate environment of housing was statistically significantly related to rural and intermediate areas (94.8% and 91.9% vs. 79.5%, urban), and to 1st and 2nd quartiles of average income (92.5% and 86.9% vs. 81.5% of the 3rd quartile and 78.6% of the 4th quartile). Housing orientation also showed a statistically significant association with dwelling type, number of cohabitants and...
Table 2
Characteristics of outdoor space and orientation of dwellings.

| Variable         | Availability of outdoor space | Type of outdoor space | Position towards immediate surroundings |
|------------------|-------------------------------|-----------------------|------------------------------------------|
|                  | Yes N (%) row) | No N (%) row) | P* | Yes N (%) row) | No N (%) row) | P* | Yes N (%) | No N (%) |
|                  |                 |                       |    |                 |               |    |            |            |
| General          | 1078 (69.5)     | 473 (30.5)            | 295 (28.5) | 642 (62.0)     | 99 (9.6)      | 116 (7.6) | 1273 (82.9) | 146 (9.5) |
| Population zone  | Urban 719 (63.2) | 418 (36.8)            | P<0.001 | 152 (21.9)     | 465 (66.9)    | 78 (11.2) | <0.001 | 111 (9.8) | 897 (79.5) | 120 (10.6) | P<0.001 |
|                  | Intermediate 260 (87.0) | 39 (13.0)            | 95 (38.3) | 136 (54.8)     | 17 (6.9)      | 3 (1.0)  | 272 (91.9) | 21 (7.1)  |
|                  | Rural 87 (88.8) | 11 (11.2)            | 44 (51.2) | 38 (44.2)      | 4 (4.7)       | 1 (1.0)  | 91 (94.8) | 4 (4.2)   |
| Average household income | 1st quartile (lowest) 145 (89.0) | 18 (11.0)           | P<0.001 | 66 (47.5)       | 69 (49.6)     | 4 (2.9)   | P<0.001 | 4 (2.5)   | 149 (92.5) | 8 (5.0)   | P<0.001 |
|                  | 2nd quartile 195 (74.0) | 68 (26.0)           | 55 (29.6) | 117 (62.9)     | 14 (7.5)      | 8 (3.1)  | 225 (86.9) | 26 (10.0) |
|                  | 3rd quartile 299 (69.1) | 134 (30.9)          | 65 (22.3) | 199 (68.4)     | 27 (9.3)      | 35 (8.2) | 349 (81.5) | 44 (10.3) |
|                  | 4th quartile 384 (62.7) | 227 (37.2)          | 97 (26.3) | 224 (60.7)     | 48 (13.0)     | 68 (11.2) | 477 (78.6) | 62 (10.2) |
| Type of dwelling | Single-family detached 135 (97.8) | 3 (2.2)            | <0.001 | 98 (75.4)       | 25 (19.2)     | 7 (5.4)   | <0.001 | 2 (1.5)   | 132 (97.1) | 2 (1.5)   | <0.001 |
|                  | Single-family semi-detached 264 (96.4) | 10 (3.6)          | 127 (49.4) | 121 (47.1)     | 9 (3.5)       | 5 (1.8)  | 251 (92.6) | 15 (5.5)  |
|                  | Studio or loft attic 141 (69.5) | 62 (30.5)          | 4 (3.1)  | 110 (84.6)     | 16 (12.3)     | 13 (6.4) | 174 (85.7) | 16 (7.9)  |
|                  | Middle floor 482 (58.0) | 349 (42.0)          | 37 (7.9)  | 364 (78.1)     | 65 (13.9)     | 80 (9.7) | 646 (78.1) | 101 (12.2) |
|                  | Ground floor 48 (52.2) | 44 (47.8)           | 28 (58.3) | 18 (37.5)      | 2 (4.2)       | 14 (15.7) | 64 (71.9) | 11 (12.4) |
| Occupancy regime | Own 828 (72.9) | 308 (27.1)          | P<0.001 | 254 (58.8)     | 76 (9.5)      | <0.001 | 66 (5.9)  | 961 (85.3) | 100 (8.9) | <0.001 |
|                  | Rented 205 (56.6) | 145 (41.4)         | 29 (14.9) | 145 (74.7)     | 20 (10.3)     | 46 (13.2) | 259 (74.4) | 43 (12.4) |
| Persons in the household | One 43 (18.0) | 196 (82.0)          | <0.001 | 37 (17.8)       | 154 (74.0)    | 17 (8.2)  | <0.001 | 43 (12.3) | 274 (78.1) | 34 (9.7)  | 0.004 |
|                  | Two 32 (5.6) | 540 (94.4)          | 72 (25.7) | 176 (62.9)     | 32 (11.4)     | 35 (8.3) | 346 (81.6) | 43 (10.1) |
|                  | Three 10 (2.8) | 352 (97.2)          | 61 (28.2) | 131 (60.6)     | 24 (11.1)     | 16 (5.0) | 271 (85.2) | 31 (9.7)  |
|                  | Four or more 8 (2.6) | 302 (97.4)         | 123 (37.6) | 179 (54.7)     | 25 (7.6)      | 22 (5.1) | 376 (86.4) | 37 (8.5)  |

*P-value for the chi-square test of the relationship between outdoor space characteristics and other housing characteristics. p < 0.05 implies statistically significant relationship.

occupancy regime. An inwards orientation was associated with living on the ground floor, single occupancy, and rented accommodation during confinement.

Enjoying one’s own outdoor space associated with rural (88.8%) and intermediate areas (87%), with lower incomes (89.0%, 1st quartile vs. 62.8%, 4th quartile), living with four or more people (77.7% vs. 62.4%, alone), living with people over 65 (77.8%), in detached (97.8%) or semi-detached (96.4%) dwellings, and in a property regime (72.9% vs. 58.6%, rented). Living with children under 18 did not show a significant relationship with the availability of outdoor space, but the proportion was higher than average (71.4%). Having a terrace or balcony during confinement related to rented accommodations (74.7% vs. 58.8%, owned) and with urban environments with higher average rents. Having a patio or garden was associated with home ownership (31.8% vs. 14.9%, renting) and rural areas with lower income levels.

3.4. Respondents’ perception on environmental quality of housing

Table 3 shows the perceived environmental quality of the dwelling according to the variable habitat and the characteristics of the households. Almost 94% of the surveyed households considered that the lighting in their homes was adequate, very adequate or
### Table 3

Perception of housing quality by household indoor environmental descriptors.

| Variable | Lighting | Indoor air quality | Noise insulation | Thermal comfort |
|----------|----------|---------------------|------------------|-----------------|
|          | Not at all/ not very adequate | Adequate/ very adequate | p* | Not at all/ not very adequate | Adequate/ very adequate | p* | Not in comfort | In comfort (neutral) | p* |
|          | N (%row) | N (%row) | p* | N (%row) | N (%row) | p* | (row) | (row) | (row) |
| **General** | | | | | | | | | |
| | 94 (6.3) | 1,405 (93.7) | 198 (13.3) | 1,293 (86.7) | 575 (38.7) | 909 (61.3) | 546 (36.8) | 937 (63.2) | |
| **Population area (habitat)** | | | | | | | | | |
| Urban | 73 (6.6) | 1,031 (93.4) | 0.659 | 159 (14.5) | 939 (85.5) | 0.054 | 444 (40.7) | 646 (59.3) | 0.009 |
| Intermediate | 15 (5.2) | 276 (94.8) | 33 (11.4) | 86 (88.6) | 106 (36.4) | 185 (63.6) | 97 (33.7) | 191 (66.3) | |
| Rural | 6 (6.5) | 86 (93.5) | 6 (6.5) | 86 (93.5) | 23 (25.3) | 68 (74.7) | 23 (25.8) | 66 (74.2) | |
| **Entry of natural light** | | | | | | | | | |
| Completely sunny | 2 (0.3) | 649 (99.7) | <0.001 | 51 (7.9) | 597 (92.0) | <0.001 | 187 (29.0) | 458 (71.0) | <0.001 |
| Sunny (some time of day) | 43 (5.8) | 702 (94.2) | 117 (15.8) | 622 (84.2) | 328 (44.5) | 409 (55.5) | 299 (40.6) | 438 (59.4) | |
| Shade | 48 (52.7) | 43 (47.3) | 28 (30.8) | 63 (69.2) | 52 (57.1) | 39 (42.9) | 47 (52.2) | 43 (47.8) | |
| **Occupancy regime** | | | | | | | | | |
| Own | 47 (4.3) | 1051 (95.7) | <0.001 | 108 (9.9) | 981 (90.1) | <0.001 | 376 (34.6) | 712 (65.4) | <0.001 |
| Rented | 38 (11.2) | 302 (88.8) | 79 (23.2) | 262 (76.8) | 177 (52.5) | 160 (47.5) | 152 (45.4) | 183 (54.6) | |
| **Type of dwelling** | | | | | | | | | |
| Single-family detached | 4 (3.0) | 128 (97.0) | <0.001 | 6 (4.6) | 125 (95.4) | <0.001 | 18 (13.8) | 112 (86.2) | <0.001 |
| S-family semi-detached | 12 (4.5) | 253 (95.5) | 23 (8.8) | 238 (91.2) | 82 (31.2) | 181 (68.8) | 87 (33.3) | 174 (66.7) | |
| Studio or loft and attic | 6 (3.0) | 192 (97.0) | 31 (15.8) | 165 (84.2) | 88 (44.4) | 110 (55.6) | 71 (36.0) | 126 (64.0) | |
| Middle floor | 48 (6.0) | 757 (94.0) | 119 (14.8) | 684 (85.2) | 345 (43.3) | 452 (56.7) | 302 (40.6) | 492 (62.0) | |
| Ground floor | 22 (24.4) | 68 (75.6) | 17 (18.9) | 73 (81.1) | 41 (46.6) | 47 (53.4) | 46 (51.1) | 44 (48.9) | |
| **Total area** | | | | | | | | | |
| <60m² | 43 (18.0) | 196 (82.0) | <0.001 | 61 (25.5) | 178 (74.5) | <0.001 | 123 (52.1) | 113 (47.9) | <0.001 |
| 60-90m² | 32 (5.6) | 540 (94.4) | 89 (15.6) | 481 (84.4) | 256 (45.1) | 312 (54.9) | 220 (38.7) | 348 (61.3) | |
| 91-120m² | 10 (2.8) | 352 (97.2) | 26 (7.2) | 335 (92.8) | 128 (35.7) | 231 (64.3) | 126 (35.5) | 229 (64.5) | |
| >120 m² | 8 (2.6) | 302 (97.4) | 20 (6.6) | 285 (93.4) | 63 (20.6) | 243 (79.4) | 84 (27.3) | 224 (72.7) | |
| **Area per person** | | | | | | | | | |
| < 30m²/person | 38 (9.3) | 371 (90.7) | 0.029 | 74 (18.1) | 334 (81.9) | <0.001 | 178 (44.1) | 226 (55.9) | 0.003 |
| 30-44m²/person | 19 (5.0) | 363 (95.0) | 47 (12.3) | 335 (87.7) | 157 (41.2) | 224 (58.8) | 132 (35.2) | 243 (64.8) | |
| 45-59m²/person | 10 (4.3) | 221 (95.7) | 36 (15.7) | 193 (84.3) | 88 (38.3) | 142 (61.7) | 82 (35.5) | 149 (64.5) | |
| >60m²/person | 26 (5.8) | 425 (94.2) | 38 (8.5) | 409 (91.5) | 143 (32.2) | 301 (67.8) | 160 (35.7) | 288 (64.3) | |

*a* P-value for the chi square test of the relationship of indoor environmental descriptors and general housing features. P < 0.05 implies statistically significant relationship.

 totally adequate, taking into account that 44% of the homes received sunlight in all their rooms at different times of the day, and 50% received it in some of the time slots. Almost 87% believed that they had good or very good ventilation in their homes. In the case of the perception of noise insulation of the dwellings, 61.3% of the households considered them adequate or very well insulated. The solar exposition showed a statistically significant relationship with the perception of lighting, ventilation, thermal comfort and air quality in the house. Having a poor or inadequate perception of the overall indoor environmental quality was associated with fewer hours of daylighting, or even in semi-darkness/shade.
The ventilation and noise insulation variables showed a statistically significant association with the habitat, and with the following dwelling characteristics: occupancy regime, type of dwelling, useful surface area and surface area per person. Being in urban areas, in a rented dwelling, living on the ground floor (vs. single-family detached), with less than 60 m², and less than 30 m²/person, were associated with a more negative evaluation of the ventilation and insulation of the house. The perception of lighting did not show a statistically significant association with the habitat, but this variable did show a significant relationship with the variables: occupancy regime, type of dwelling, useable floor area and floor area per person. They presented the same distribution pattern as in the ventilation and acoustic insulation variables. The perception of the quality of the home did not show a statistically significant relationship with the average income level, with the exception of the lighting variable.

Lastly, thermal comfort showed to be statistically significant with the main housing aforementioned features (habitat, sunshine exposition, occupancy regime, type of dwelling, and useable floor area), except area per person. Being in thermal discomfort was related to urban areas, dwelling surfaces lesser than 90 m², flats on the ground and intermediate floors, rented, and partially or totally shaded.

3.5. Expectation of different changes or adaptations in housing, due to COVID-19 confinement

74.6% of the surveyed households wished to make some kind of change or adaptation to their dwellings. Fig. 1 showed the percentage of households that wanted to make changes to any of the housing characteristics described. 41.9% wanted to change the available exterior space (terrace, patio, balcony, porch); 36.5% to adapt the thermal-acoustic insulation conditions of their dwelling; 27.1% to change the housing size; 21.8% would like to modify their storage spaces; 21.3% desired better window quality; 17.7% wanted to have pleasant exterior views; 11.7% wanted to improve the natural lighting in their homes; and 6.5% would change other facilities (power, sanitation and/or domestic water, …).

The variable "expectations of change" showed a statistically significant relationship with the habitat and with housing characteristics. Wanting to make modifications/adaptations to the dwelling was associated with living in urban areas, living in a studio, attic or ground floor, having less useable area, and living alone and renting. Likewise, living in rented accommodation showed a statistically significant positive association with the desire to change some of the housing characteristics described in Fig. 1: exterior space, thermal-acoustic insulation, housing size, storage space, window quality and external views, natural lighting, and other facilities.

3.6. Multivariate model based on binary logistic regression

Table 4 shows the relations among dwelling characteristics, cohabitants’ features and the design dissatisfaction.

The three variables that showed a significant relationship with the variable “housing dissatisfaction” were: useable floor area, the type of housing, and the occupancy regime.

The ORs indicate that dissatisfaction with the design of the dwelling in terms of probability would occur 2.4 times more in dwellings with less than 90 m², than with more than 90 m² (p < 0.001); with 2.21 times more in multi-family homes (flats) than in single-family ones (p < 0.001); and 1.6 times more in rental housing than in property. The rest of the variables introduced, showing previously a bivariant relation with the variable (habitat, number of persons cohabitating, or having or not pending payments - mortgages or similar-), did not show any causal relationship with the dependent variable.
Table 4
Model of binary logistic regression based on the degree of housing-design dissatisfaction, related to dwelling and cohabitants’ characteristics.

| Variable                  | B   | Standard error | Wald | df | Sig. | Exp(B) |
|---------------------------|-----|----------------|------|----|------|--------|
| Average household income  | 0.600 | 0.176          | 0.114 | 1  | 0.736 | 1.061  |
| Useable floor area        | 0.883 | 0.171          | 26.731 | 1  | <0.001 | 2.417  |
| Persons in the household  | 0.163 | 0.155          | 1.105 | 1  | 0.293 | 1.177  |
| Type of dwelling          | 0.793 | 0.177          | 20.010 | 1  | <0.001 | 2.210  |
| Habitat                   | 0.057 | 0.187          | 0.092 | 1  | 0.761 | 1.058  |
| Housing expenses          | 0.014 | 0.163          | 0.007 | 1  | 0.933 | 1.014  |
| Occupancy regime          | 0.463 | 0.232          | 3.989 | 1  | 0.046 | 1.589  |
| Constant                  | 0.357 | 0.219          | 2.66  | 1  | 0.103 | 1.429  |

* P-value < 0.05 implies statistically significant relationship among variables.

4. Discussion

According to official sources, 18,754,800 households were confined in Spain during the spring of 2020. Considering that the average number of household members was 2.5 persons, this meant more than 37 and a half million individuals staying in their homes for more than 3 months throughout the national territory. As for the composition of these households, 26.1% were single-person households, 54% lived in couples, and among these, 33.1% were couples with children, and 10.4% of the total were single-person households with children [53].

In terms of habitat, the sample was mainly located in urban environments (73.4% vs. 54% as official data). According to the number of inhabitants, the official data indicate that 68.9% of the households were located in towns with more than 20,000 inhabitants [37]. Four out of every ten households in the sample (41%) were situated in municipalities in the highest income quartile. Households in intermediate and rural areas were in municipalities with lower incomes.

Of the sample, half of the dwellings were mid-rise apartments (54%), and 9% were single-family detached houses, houses in the countryside or in the mountains, contrasting with 13.9% of official single-family detached houses [37]. Looking at these data, the 2019 European average reported a lower urban density, as on average, 46.1% of the European population lived in apartments (from 8.2% in Ireland, or 20.5% in the Netherlands, compared to 62.2% in Switzerland, or 65.9 in Latvia, in 2019). More than a third live in detached houses, and almost a fifth live in semi-detached or terraced ones [54]. More than a quarter of the households (28.5%) had four or more people living together. On average, the dwellings had 52.1 m² per cohabitant, a more than fairly reasonable surface area per person, giving an average useful living area of about 130 m² for the sample. Official data showed that 45.5% of the houses had a useable floor area between 61 and 90 m², while almost the other half, 41.7%, had more than 90 m². Only 12.7% were properties smaller than 60 m² [37].

Being located in urban areas, and in localities with higher average household incomes, was associated with having a lower number of useable square meters of floor space (between 60 and 90 m²), living in apartments or attics, and living alone or as a couple. This was also in line with the Eurofound report, which found that living in rural areas generally tended to have the highest average number of rooms per person [55].

More than two-thirds of the households surveyed (76%) during confinement were owned, which is consistent with the European average, which by 2019 estimated 69.8% of people living in owner-occupied housing [54]. In the study, these owned dwellings were associated with rural environments, municipalities with lower income levels, and a larger number of people living together. The overcrowding rate, defined as the percentage of households below the minimum number of rooms per person, according to the total number of people in the household, the family situation, and their age [54], was very low in Spain in general (around 5–8%), and did not depend on the degree of urbanization [56]. In contrast, the European average was between 15% in intermediate cities and 20% in cities [54].

According to official European reports, there is a paradox of a demographic slowdown, but increasingly in Europe there is a shortage of adequate housing. This suggests a change in the composition of households, with an increasing proportion of people living alone, while the number of large family households is decreasing [54].

Eight out of ten households surveyed (82.9%) were outward-facing. Enjoying one’s own outdoor space was associated with living in rural environments and intermediate areas, in municipalities with lower incomes, in single-family dwellings, with more people living together, and with ownership. Having a terrace or balcony during confinement was associated with living in urban areas and renting. Whereas having a patio or garden was associated with rural areas with lower income levels and with home ownership. This might be linked to two different, although related, factors: 1) living in rural areas was more associated with the idea of permanence, in a certain way due to the identity with the place (since we are talking about the main dwelling), while in the city there was a higher percentage of people passing through, 2) the outdoor recreation area in the domestic sphere continued to respond mostly to a typology, in accordance with the surface area and building density. Having terraces and balconies corresponded to a high-rise model, more typical of the city, while having a large horizontal space, such as a garden or patio, was more typical of more rural areas and, therefore, with average household incomes that were generally lower than in the city. This agrees, with the study by Manso et. Al, with individuals with higher social class who is used to living without green spaces [57].

The design of the built environment, beyond the dwelling as a unit, has a decisive effect on the habitability of the house, through the solar potential [58]. One of the aspects that define it is orientation and sunlight [59], referring both to the position in relation to the cardinal points (and therefore to solar movement throughout the day and the seasons of the year), and to the relative position...
with respect to the capable volume of the building itself and those of the surroundings. This occurs not only because of the light itself, or the absence of it due to shadows cast by the building, or due to the vague or non-existent entry of natural light, but also to the total energy consumption, for heating, [60], and for other services, such as lighting [61]. The perception of lighting did not show a statistically significant association with the type of habitat.

Almost all the households surveyed considered the lighting and ventilation of their homes very adequate. 61.3% valued their homes adequately insulated. This statement is aligned with others that see the lighting and ventilation as housing preferences for users [62]. On the other hand, these values also coincide with what was established in the National Housing Barometer (2018), which established that 34% of the population was dissatisfied with the insulation against the heat or cold of their homes (36.8% according to this study results), while 35.8% was dissatisfied with the noise insulation [37].

Being located in urban areas, in rented flats, living on the ground floor, having a floor area lesser than 60 m² (90 m² for thermal comfort), receiving fewer hours of natural light per day, were associated with a more negative evaluation of the indoor environmental quality of the house (lighting, thermal comfort, air quality and insulation in the dwelling). This is in agreement with Pedersen et al., who stated that control over indoor environmental quality falls mainly on the owner, while tenants can only act to a limited extent on certain aspects of daily regulation, which would explain their more negative perception [63]. Not surprisingly, in actions on existing dwellings to improve indoor environmental quality, tenants have reported such improvements not only thanks to the upgrading of the dwellings, but also to having received information and when they exist, in the control and regulation of the devices [64]. In fact, as another study points out, ventilation patterns do not necessarily have to respond to better or worse perceived air quality, but rather to thermal comfort criteria, or lack thereof [65].

These habitation aspects of the built environment, which are clearly linked to the well-being and health of people, have become more important due to the serious impact that COVID-19 has had not only on health, but also on socioeconomic, energy and environmental aspects for the whole world [66].

On indoor environmental quality, encouraging daily actions such as ventilating or using solar control devices to take advantage of air breezes and natural light, can avoid other undesirable effects at this time of uncertainty, where the population may fall into the relaxation of health measures when other apparently more popular or perceived as more effective measures have been applied [67].

Finally, it must be considered that the dwelling during the confinement was erected as the bastion of protection of the population. And, therefore, it has been possible to note a certain positive perception of having to make "a virtue out of necessity", assuming the reality due to the imperative of urgency and the condition of temporariness. Nevertheless, as our internal needs in the home changed in part (for example, how to share spaces with other cohabitants, even how to isolate people at risk, health workers, or possible infected persons), households demanded a level of adaptation or spatial, functional, or environmental change to their homes. 74.6% of the households surveyed wanted to make some type of change or adaptation to their homes. This desire for home modifications/adaptations was associated with living in urban areas; in a studio, attic or first floor apartment; having less usable floor space; and living alone and renting. Some of these aspects might be related to the condition of control that the status of ownership confers on the home itself, having better conditions in terms of habitability due to a greater solar potential in higher and more spacious homes. Also, it might be related to the level of commitment and at the same time social exchange involved in living with others, which, according to many studies, facilitated resilience levels by having more important vital purposes that kept our minds occupied in the face of possible negative and stressful thoughts [68].

The dissatisfaction was related to the usable floor area, taking into account that during confinement the spaces had to be adapted for different uses [69]. With regard to the type of housing, in addition to the differences in comfort offered by the different types, it could condition a greater risk of spreading the coronavirus [70]. Occupancy regime conditions the investment that owners or tenants are able to make in the home, taking into account that the differences in ownership affect the maintenance of the property, conditioning the safety and health of the owners and tenants [71].

Such studies demonstrate that the need for multidisciplinary analyses that address complex phenomena, such as this worldwide pandemic, are essential, since the impacts, and therefore the strategies to mitigate or anticipate them, cannot be addressed independently. The home has been the physical nucleus where all the activity of confined people has been carried out. However, the built environment, the urban design, the habitat, and the characteristics of the home and its inhabitants have decisively conditioned the way of perceiving satisfaction with the dwelling and its degree of adaptation to this disruptive event.

There are two main limitations to this study. The first is defined by the exploratory nature of the study itself, which nevertheless wanted to take advantage of the urgency and timeliness of the situation to address it "in the heat of the moment". Nonetheless, as it is not a probabilistic study, it would be interesting to be able to develop strategies for designing representative studies, both to be able to do so in similar future scenarios, and to evaluate the real extent of these perceptions, once the disruptive effect ceases, and the population returns to its normal life. Also, a longitudinal cohort study would have been desirable, in order to properly compare the needs and requirements from households before, during and after COVID-19 lockdown, to distinguish influencing factors and nuances among periods, their lived experiences, and respective needs, as well as if they were satisfied by housing quality and design for each moment.

Secondly, to highlight the methodological simplification of the economic indicator, relating to the average household income, established by quartiles, which has been set according to the municipal average, excluding towns with less than 500 inhabitants. This simplification is explained by not having asked households about household economy issues, as it seems to be a sensitive subject and in order not to provoke rejection and abandonment of the questionnaire.

As possible lines for future research, two are clearly pointed out: 1) methodological, on the systematization of the approach of studies of this type, in the face of possible future contingencies that require "on the spot" studies, which help to analyse and generate new discourses on "inhabiting" and "resilience" in the face of unpredictable or unimaginable scenarios; and 2) the generation of co-
horts to analyse, if possible, the before, during and after, through longitudinal and follow-up studies, allowing not only quantitative but also qualitative and personalized analysis, in order to know if the perception of the disruptive event is continuous, if it has left a learning or a "dent" in the individual, in the household or in the community, or if on the contrary, when these specific needs or this disruptive element cease, and with uncertainty, the demands attributed to the dwelling in the "during" would not be necessary anymore, in the "after".

Lastly, these functional and environmental analyses of the building stock should be approached on a multi-scale, both at the habitat or territorial level (house, building, neighbourhood, city ...), and at the collective level (cohabitant, home, building, community), in order to qualify or bring out common and differentiating aspects that can help in the elaboration of these new discourses of inhabiting, and especially in the case of emergencies, whatever their nature may be. To this end, it is advisable to use multidisciplinary teams and a mixed approach, both quantitative and qualitative, to enrich learning towards healthier, more sustainable, and resilient models.

The implications in relation to knowledge about the habitability of the housing stock occupied on a regular basis (first home) are related to the need to taxonomize these dwellings, find out which parameters have been more satisfactory, and which have not, define possible causes, and contrast this with those variables objectively related to the healthiness and well-being of their inhabitants. From the crossing of the subjective and the objective, the complete discourse emerges to be able to qualify which aspects have been key in the personal experience of the respondents during the confinement, and which have been dispensable. This provides a valuable and unique testimony to work on for housing designers and rehabilitators, urban design, and planning professionals, on the one hand, and for policy makers and health authorities, on the other. The joint work of all these actors is key to develop best practice guidelines, recommendations, as well as strategies and contingency plans, assistance where appropriate, and relief in the event of future extreme situations.

5. Conclusion

The present work aimed to analyse and evaluate the characteristics of Spanish dwellings occupied in COVID-19 confinement, in order to taxonomize them, according to the needs, perceptions and expectations surrounding the housing in the context of COVID-19 lockdown. Specially, three main aspects were explored: the relations with outdoor space, the indoor environmental quality, and the dissatisfaction with the housing, in terms of design and constructive features (not easily changeable), which were crossed with domestic and households’ characteristics, to define relations among variables and overall home profiles.

On the relations with outdoor space, dwellings with outdoor spaces and/or good orientation were related to rural or intermediate habitats, home ownership, lower incomes, more cohabitants. People living in cities occupied rented flats, with lesser usable floor surface, with no outdoor space, or if so, terraces of balconies, living alone or with couple, and upper incomes.

According to the results obtained for indoor environmental quality (in terms of lighting, noise insulation, thermal comfort and air quality), most of people were generally satisfied with natural lighting and air quality. Almost 40% were not satisfied with noise insulation. Living in urban areas, with a poor sun exposition, in rented flats and thus, with lesser usable floor surface, were related to be dissatisfied with indoor environmental quality.

Related to housing expectations and domestic desired changes, Two thirds of households wanted to do some change, highlighting outdoor space, overall insulation and housing size. People more likely to want home changes were those living alone, rented in small flats, and located at ground floor or attics. Finally, housing design dissatisfaction associated with useable floor area, type of housing, and occupancy regime, following the multivariate model of logistic regression.

The results of this work reveal that people in cities are more likely to live in overall discomfort, with high levels of home dissatisfaction, due to their situation of non-permanence, or difficulty to buy a house. This conclusion has two readings: First, housing building design has to be re-thought, bearing in mind new and potential needs emerged or intended, and encouraging affordable quality housing; and second, policies and incentives for renovation of rented housing need to be boosted, so home owners invest in their properties to update the current housing stock, specially in large cities, improving people’s quality of life and well-being. Both are urgent, tackling next-future scenarios of Climate Change, thermal extremes, and potential emergency events that may require long home-stays.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.
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References

[1] C. Sohrabi, et al., World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19), Int. J. Surg. 76 (01-Apr-2020) 71–76 Elsevier Ltd.
[2] A. Abellán García, et al., Una visión global de la pandemia COVID-19: qué sabemos y qué estamos investigando desde el CSIC; Informe elaborado desde la Plataforma Temática Interdisciplinar Salud Global/Global Health del CSIC, Consejo Superior de Investigaciones Científicas, España, 2021.
[3] World Health Organization, 2019 Novel Coronavirus (2019-nCoV): Strategic Preparedness and Response Plan’, Feb-2020.
[4] M. Jamies Torres, M. Aguilera Portillo, T. Cuervo-Vilches, I. Oteiza, M.A. Navas-Martín, Habitability, resilience, and satisfaction in Mexican homes to COVID-19 pandemic, Int. J. Environ. Res. Public Health 18 (13) (Jun. 2021) 6993.
[5] T. Cuervo-Vilches, M.A. Navas-Martín, Indicators of satisfaction and habitats of occupation of the mayores españoles en sus viviendas durante el confinamiento COVID-19, WSR Rev. Int. Sustain. Hous. Urban Renew. (9–10) (Dec. 2020) 66–82.
[6] Gobierno de España, Real Decreto 463/2020, de 14 de marzo, por el que se declara el estado de alarma para la gestión de la situación de crisis sanitaria ocasionada por el COVID-19, BOE, Mar., 2020.
[7] T. Kalmár, F. Kalmár, Investigation of natural aeration in home offices during the heating season – case study, J. Build. Eng. 35 (Mar. 2021) 102052.
[8] T. Cuervo-Vilches, M.A. Navas-Martín, S. March, I. Oteiza, Adequacy of telework spaces in homes during the lockdown in Madrid, according to socioeconomic and home features, Sustain. Cities Soc. 75 (Dec. 2021) 103262.
[9] T. Cuervo-Vilches, M.A. Navas-Martín, Confined spaces: a visual-emotional analysis of study and rest spaces in the homes, Int. J. Environ. Res. Public Health 18 (11) (May 2021) 5506.
[10] J.C. Palomino, J.G. Rodríguez, R. Sebastian, Wage inequality and poverty effects of lockdown and social distancing in Europe, Eur. Econ. Rev. 129 (Oct. 2020).
[11] T. Cuervo-Vilches, M.A. Navas-Martín, M. Arroyo, Estudio (COVID-HAB-PAC): un enfoque cualitativo sobre el confinamiento social (COVID-19), experiencia y adaptabilidad en pacientes crónicos y su entorno, Paranimfo DIGIT., Nov. 2020 e23075e@e230750.
[12] Gobierno de España, Plan para la transición hacia una nueva normalidad, Apr. 2020.
[13] Notarios y Registradores, Resumen Real Decreto Ley coronavirus, 21/2020, de 9 de junio: Nueva Normalidad, Plazos registrales, ’Jun-2020.
[14] K. Sarah, S. Oceane, F. Emily, F. Carole, Learning from lockdown - assessing the positive and negative experiences, and coping strategies of researchers during the COVID-19 pandemic, Appl. Anim. Behav. Sci. 236 (Mar. 2021) 105269.
[15] M.A. Navas-Martín, J.A. López-Bueno, I. Oteiza, T. Cuervo-Vilches, Routines, time dedication and habit changes in Spanish homes during the COVID-19 lockdown. A large cross-sectional survey, Int. J. Environ. Res. Public Health 18 (22) (Nov. 2021) 12176.
[16] A. Cheshmezhangi, COVID-19 and household energy implications: what are the main impacts on energy use? Helioyan 6 (10) (Oct. 2020).
[17] P. Devine-Wright, L. Pinto de Carvalho, A. Di Masso, M. Lewicka, L. Manzo, D.R. Williams, Replaced - reconsidering relationships with place and lessons from a pandemic, J. Environ. Psychol. 72 (Dec. 2020) 101514.
[18] F. de Frutos, Ind. environmental quality and consumption patterns before and during the COVID-19 lockdown in twelve social dwellings in Madrid, Spain, Sustainabilty 13 (14) (Jul. 2021) 7700.
[19] T. Cuervo Vilches, I. Oteiza San José, M.Á. Navas Martín, Proyecto sobre confinamiento social (coivid-19), vivienda y habitabilidad (COVID-HAB-PAC), Paranimfo 14 (32) (2020) e230660.
[20] Paranimfo DIGIT, M.A. Navas-Martín, I. Oteiza, Behavior patterns, energy consumption and comfort during COVID-19 lockdown related to home features, socioeconomic factors and energy poverty in Madrid, Sustainabilty 13 (11) (May 2021) 5949.
[21] Organización Mundial de la Salud, Directrices de la OMS sobre vivienda y salud, resumen de orientación’, Geneva, 2018.
[22] M. Zarrabi, S.A. Yazdanfar, S.B. Hosseini, COVID-19 and healthy home preferences: the case of apartment residents in Tehran, J. Build. Eng. 35 (Mar. 2021) 102021.
[23] E. Megahed, M.E. Ghoneim, Antivirus-built environment: lessons learned from Covid-19 pandemic, Sustain. Cities Soc. 61 (Oct. 2020) 102350.
[24] S. Domínguez-Amarillo, J. Fernández-Agúera, M.M. González, T. Cuervo-Vilches, Overheating in schools: factors determining children’s perceptions of overall comfort, Sustain. Cities Soc. 12 (4) (Jul. 2020) 5772.
[25] Agency USA EPA, “Indoor Air Quality Indicators Radon: Homes at or above EPA’s Action Level Serum Cotinine Related Links Indoor Air Quality Air Research what are the Trends in Indoor Air Quality and their Effects on Humans?”.
[26] World Health Organization, Household air pollution and health, WHO Media Centre. (May 2018) (2018) 3–7.
[27] C. Muñoz-González, et al., Natural lighting in historic houses during times of pandemic. The case of housing in the Mediterranean climate, Int. J. Environ. Res. Public Health 18 (14) (Jul. 2021) 7264.
[28] E. Díaz Lozano Patino, J.A. Siegel, Indoor Environmental Quality in Social Housing: A Literature Review, vol. 131, Elsevier Ltd, 01-Mar-2018, pp. 231–241 Building and Environment.
[29] C. Ll. H. Tang, Study on ventilation rates and assessment of infection risks of COVID-19 in an outpatient building, J. Build. Eng. 42 (Oct. 2021) 103090.
[30] D.R. Culqui, et al., Short-term influence of environmental factors and social variables COVID-19 disease in Spain during first wave (Feb-May 2020), Environ. Sci. Pollut. Res. Int. (Mar. 2021) 1–15.
[31] ASHRAE, Standard 55 – thermal environmental conditions for human occupancy [Online]. Available: https://www.ashrae.org/technical-resources/ bookstores/standard-55-thermal-environmental-conditions-for-human-occupancy, 2020.
[32] AENOR-UNE. UNE-EN ISO 7790:2006 Ergonomía del ambiente tórmico. Determination, 2006.
[33] P. Lourenço, M.D. Pinheiro, T. Heitor, Light use patterns in Portuguese school buildings: user comfort perception, behaviour and impacts on energy consumption, J. Clean. Prod. 228 (2019) 990–1010.
[34] D. D’ Alessandro, et al., COVID-19 and indoor living space challenge. Well-being and public health recommendations for a healthy, safe, and sustainable housing, Acta Biomed. 91 (2020) 61-75.
[35] J. Díaz, J.A. López-Bueno, D. Culqui, C. Asensio, G. Sánchez-Martínez, C. Linares, Does exposure to noise pollution influence the incidence and severity of COVID-19? Environ. Res. 195 (Apr. 2021).
[36] Gobierno de España, De la estrategia a largo plazo para la rehabilitación energética en el sector de la edificación en España, Jun, 2020.
[37] F. Asim, P.S. Chani, V. Shree, Impact of COVID-19 containment zone built-environments on students’ mental health and their coping mechanisms, Build. Environ. 203 (Oct. 2021) 108107.
[38] M. Marqués, J. Rovira, M. Nadal, J.L. Domingo, Effects of air pollution on the potential transmission and mortality of COVID-19: a preliminary case-study in Tarragona Province ( Catalonia, Spain), Environ. Res. 192 (Jan. 2021) 110315.
[39] S. Perez-Bezos, A. Figueroa-Lopez, M. Etchezbarria-Mallea, X. Oregi, R.J. Hernandez-Mingullon, Assessment of social housing energy and thermal performance in relation to occupants’ behaviour and COVID-19 influence—a case study in the Basque country, Spain, Sustainability 14 (9) (May 2022) 5594.
[40] T. Peters, A. Hallen, How our homes impact our health: using a COVID-19 informed approach to examine urban apartment housing, Archnet-UAR 15 (1) (Mar. 2021) 10–27.
[41] M. Zarrabi, S.A. Yazdanfar, S.B. Hosseini, COVID-19 and healthy home preferences: the case of apartment residents in Tehran, J. Build. Eng. 35 (Mar. 2021) 102021.
[42] A. Hamida, D. Zhang, M.A. Ortiz, P.M. Bluyssen, ‘Students’ Self-Reported Health and Psychosocial Status at Home before and during COVID-19’, CLIMA 2022
