



QUESTIONNAIRE ON NOISE PERCEPTION IN SPANISH HOMES DURING THE COVID-19 LOCKDOWN

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ABSTRACT

Due to the exceptional pandemic containment measures and the lockdown imposed because of the COVID-19 sanitary crisis, Spanish citizens were quarantined and they had to spend more time at home than usual. In general terms, this situation led to a reduction of environmental noise levels, whereas neighbour noise increased and thus noise annoyance to indoor noise sources in homes.

This paper shows a study based on an online questionnaire aimed at knowing the opinion of Spanish people on the acoustic conditions of their homes and how confinement measures have influenced the way they perceive indoor sounds and annoyance caused by them in their dwellings. The communication analyses noise sources in buildings, the annoyance caused by them and the satisfaction of users with the acoustic insulation of their homes.

A total of 582 responses were collected for the questionnaire, which included objective questions, such as personal data and characteristics of the dwellings, and subjective data, such as the noise annoyance before and after the lockdown. The questionnaire was composed of multiple-choice questions, closed-ended questions and others, to discover the intensity of occupant perception in relation to noise annoyance.

Keywords: *acoustic insulation, lockdown, questionnaire.*

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1. INTRODUCTION

On March 11, 2020, the World Health Organization declared COVID-19 a pandemic [1] due to the alarming levels of spread and severity of the disease, calling on countries to take urgent measures and all sectors of society to participate in the fight against the coronavirus.

Therefore, to avoid the transmission of this disease, on March 14, 2020, the Spanish government declared a state of alarm [2] in which the free movement of individuals was prohibited, limiting it to essential activities. These exceptional situations caused a change in habits [3] in the population at all levels: labour, personal, care and conciliation, etc. The imposition of social separation and home confinement forced companies to adopt measures such as teleworking, which exponentially increased [4], which in turn increased the time spent in homes, and, therefore, the noise produced in them.

This change in habits in the Spanish population, contributed to a notable decrease in ambient noise levels as shown by various studies in some of the most important cities in the country such as Madrid [5], Barcelona [6], Granada [7] or Gerona [8]. However, neighbourhood noise levels increased, increasing the discomfort caused by it in homes. This perception of neighbourhood noise, the well-being of occupants, and sound landscape are influenced by different factors: acoustic, housing construction, urban, and personal factors of the individual. [9]

Taking into account these conditions, the Acoustics Group of the Building Quality Unit of the Eduardo Torroja Institute for Construction Sciences (IETcc) of the Spanish National Research Council (CSIC), in collaboration with

the Spanish Acoustics Society (SEA) and with Spanish representatives of the Young Acousticians Network (YAN), designed a study to know the perception of the population in Spain about the acoustic conditions of their homes. This study was framed within the activities of the International Year of Sound 2020 (IYS2020) [10] and was carried out through an online survey throughout the national territory in the months of June and July 2020 when the total confinement situation had already been reversed [11] and the population was in transition to the new normality, with Spanish provinces in different phases of de-escalation [12].

In this communication, the different sources of noise and the discomfort derived from them are shown and analyzed. In addition, the paper presents the results related to the importance that users give to the acoustic insulation of their homes and the degree of satisfaction they show with the acoustic environment of their homes. On the other hand, the results of acoustic sensitivity are indicated. In all cases, the situations before and during confinement are compared.

2. MATERIALS AND METHOD

This work evaluates, through an online questionnaire, the perception of the population in Spain regarding the acoustic conditions of their homes and their way of perceiving noise and disturbances caused by it in the periods before and during the COVID-19 lockdown.

2.1 Sample. Data collection for the study

An online questionnaire was conducted to understand the perception of the Spanish population and the noise-related disturbances in their homes during the lockdown in comparison to the previous situation. The survey was available from June 26 to July 24, 2020, through the online survey management software Google Forms [13], which allowed the data to be collected under the conditions of confinement and social isolation through a simple and easily distributable interface. The link to participate in the online questionnaire was distributed through the websites of the institutions involved, email distribution lists, and social networks. The survey link was accompanied by an informed consent and information letter for the participants, explaining the objective of the study, the confidential treatment of their data, and the anonymity of the responses. The research activity was approved by the Ethics Committee of the CSIC (Favorable evaluation report ref. 112/2020).

A total of 582 responses were collected, of which 565 were considered valid and processed. All response data were collected and managed from a database in Microsoft Excel software.

2.2 Questionnaire design

The survey model used is based on a previous questionnaire designed in COST Action TU0901 [14], in which the IETcc-CSIC acoustics group participated.

The questionnaire used in this work is titled "Questionnaire on the perception of noise in homes during the COVID-19 lockdown." It consists of 52 questions that can be grouped into five sections, with an estimated time to complete of 10 minutes.

Table 1. Questionnaire contents

Personal, demographic, and employment status data	Age, gender, education, occupation, and teleworking.
Housing and sound environment data	Type of housing, size, year of construction, outdoor spaces, proximity to transport routes or commercial/leisure areas.
Comparison of annoyance due to different noise sources (before/during the confinement period)	Annoyance due to different noise sources: Noise in general and common noise sources in buildings (neighbours, common areas, facilities, etc.)
Perception of the new sound environment and user behaviour in their home's assessment of the new sound environment.	Behaviour adopted to deal with the noise generated (given the new activities carried out at home during confinement: work and school from home, relaxation, entertainment, and games).
Emotional and health response to the sound environment and satisfaction with acoustic insulation in the home (before/during the confinement period)	Acoustic insulation significance. Satisfaction with the acoustic environment of the home. Sensitivity to noise. Impact on health (sleep disturbance, anxiety, stress, lack of concentration, irritability, or others).

The questionnaire includes both objective and subjective questions, using closed-ended single-choice and matrix questions, and yes/no questions. To assess the intensity of

the user's perception of noise-related discomfort, the Likert scale has been used, with unipolar and bipolar 5-point verbal scales [15, 16, 17, 18], ranging respectively from "not at all" to "extremely" and from "much less than before" to "much more than before" (about the comparison of the sound environment before/during confinement).

3. RESULTS

This section analyzes, on the one hand, the description of the sample and, on the other hand, the results obtained from the analysis of the annoyance caused to the respondents by the different sources of noise before and during the confinement period.

3.1 Descriptive analysis

The questionnaires were answered throughout the national territory, with a majority of participants in the Community of Madrid, accounting for 48% of the total respondents.

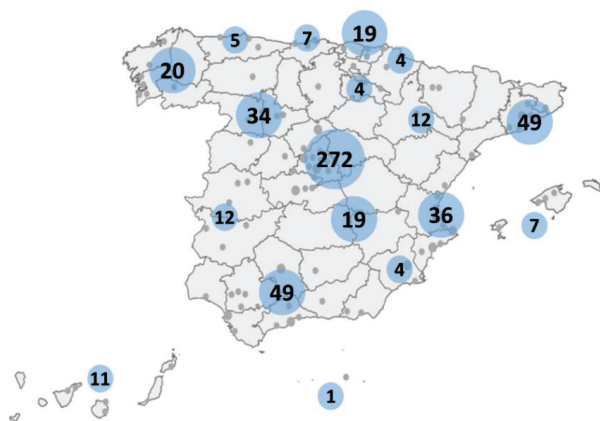


Figure 1. Location of the participants throughout the Spanish geography grouped by Autonomous Communities.

As shown in Table 2, the majority of participants (67%) are in an age range between 40 and 64 years, with very similar participation of men and women, with male participation slightly higher (53%). Likewise, 86% of respondents have university studies, and more than 84% of the surveyed population was in full-time employment, while only the remaining 16% were in unemployment, retirement, or similar situations. In addition, 75% of individuals were in a teleworking situation during the confinement period.

Table 2. Socio-demographic data.

	Options	F	%
Gender	Men	301	53%
	Women	264	47%
Age	18-25	19	3%
	26-39	125	22%
	40-64	376	67%
	≥65	45	8%
Studies	Without studies	2	0%
	Primary	8	1%
	Secondary	70	12%
	University	485	86%
Employment	Employee	473	84%
	Unemployed	47	8%
	Others	45	8%
Teleworking	Yes	423	75%
	No	142	25%

The survey was aimed at the entire population, however, the data shown above indicates a sampling bias with a majority representation of individuals of similar age, with high qualifications and employed, compared to the total respondents. As for the characteristics of the homes where the respondents lived during the confinement period, it should be noted that 80% of individuals lived in an apartment within a high-rise building, compared to 14% who lived in an attached house and only 6% in a detached house. This data reflects a higher exposure to noise in most respondents due to adjacent neighbours, a situation that does not occur in isolated homes. Another characteristic of the surveyed residences is that 76% of them had some outdoor space, such as balconies, patios, or terraces. Additionally, concerning the year of construction of the homes, it should be noted that the vast majority of the buildings under study, 94%, are constructions before the approval of the Basic Document of Protection against Noise, DB HR, of the Technical Building Code, CTE [19]. Of all of them, 52% are under the previous regulation, Basic Building Code, NBE-CA-88 [20], with the remaining 40% being before it and therefore without acoustic requirements. Only 6% of the buildings were constructed after 2010 with current regulations and existing noise insulation requirements. Finally, regarding the external sound environment around the home, approximately one fourth of the population is exposed to sources of external environmental noise such as transport routes within 150 meters (highway, motorway, urban expressway, railway tracks) (26%), aircraft noise (22.3%), and noise from commercial and leisure activities (23.7%).

Table 3. Dwelling data.

	Options	F	%
Type	Apartment	452	80%
	Attached house	79	14%
	Detached house	34	6%
Construction year	<1988	237	42%
	1988-2010	295	52%
	>2010	33	6%
Outdoor space	No	134	24%
	Yes, balcony	125	22%
	Yes, terrace	184	33%
	Yes, patio	122	22%
External noise Transport routes < 150 meters	Yes	147	26%
	No	418	74%
Aircraft noise	Yes	126	22%
	No	439	78%
Commercial Leisure act.	Yes	134	24%
	No	431	76%

3.2 Comparison of noise annoyance before and during confinement

The discomfort derived from the noise produced by the different noise sources in buildings varies depending on the noise itself (frequency, volume) and personal factors of the individual such as sensitivity or previous experiences [21]. For the study of these discomforts, participants were asked, in comparison to life before confinement, to what extent different noise sources bothered them using the following verbal scale: much less than before the confinement period, somewhat less than before the confinement period, the same as before the confinement period, somewhat more than before the confinement period, or much more than before the confinement period. The results related to the discomfort caused by the noise sources considered for the study are described below: general noise, noise produced by family members inside the home, noise from neighbours, noise from common areas, facilities, and exterior noise. The tables collected in this section (Tables 4 to 7) are expressed in frequency response percentages for each noise source according to the scale described above. Both the discomfort caused by general noise and by family members did not vary greatly compared to the situation before confinement. As shown in Table 4, 50% of the surveyed population reported that the disturbance caused by general noise was the same as before the confinement period, with a minority of 15% reporting less discomfort than before and 35% indicating that the noise disturbed them more than before that period. Likewise, noise caused within the same family unit is considered equally bothersome in 62% of cases as in

the previous period, with only 27% of respondents reporting an increase in discomfort.

Table 4. Discomfort caused by general noise and family members in comparison to life before confinement.

	General noise		Family members	
	F	%	F	%
Much less	37	7%	34	6%
Some less	43	8%	26	5%
The same	284	50%	348	62%
Some more	137	24%	104	18%
Much more	64	11%	53	9%

Regarding neighbourhood noise, in table 5, several noise sources were taken into account, differentiating whether the discomfort came from noise related to acoustic insulation from airborne noise such as people talking, music equipment, television, etc. (distinguishing between noise that came through walls and noise that came through the ceiling), or noise related to impact insulation such as footsteps or vibrations. In all cases analyzed, more than 50% of respondents reported having the same discomfort caused by noise as before the pandemic, with a minimal percentage, around 10%, indicating less discomfort than before, and approximately 35% experiencing more discomfort than before the lockdown, with everyday noises such as people talking or music and television equipment being somewhat more bothersome than those produced by footsteps or vibrations.

Table 5. Discomfort caused by neighbourhood noise.

	Wall	Ceiling	TV equip	Footsteps	Vibrations
Much less	5%	5%	5%	5%	5%
Some less	6%	6%	4%	4%	4%
The same	50%	52%	52%	58%	63%
Some more	23%	22%	24%	18%	18%
Much more	16%	15%	14%	15%	10%

In the case of communal staircases, balcony access, etc., the discomfort was analyzed both from people talking or closing doors, as well as from noises caused by footsteps or other impacts. More than 56% of the surveyed sample considers that the noise disturbs them the same as in the

previous period, with only 27% of respondents stating that they perceive more airborne noise than before and 24% who do so related to impact noise.

In relation to the building facilities, three types of facilities were distinguished:

- Water facilities: plumbing, toilet use and discharge, shower, etc.
- Individual air conditioning facilities inside the dwelling such as heaters, air conditioning, radiators, and fans.
- Centralized building facilities or located outside the dwelling, but can be heard inside, such as elevators, laundry rooms, central air conditioning, etc.

The discomfort caused by the facilities did not increase during the confinement period compared to the previous period, with more than 70% of respondents reporting the same level of discomfort as before the pandemic. Only an increase in discomfort caused by water facilities was observed, where 21% experienced more disruptions than before the study (16% "somewhat more than before the confinement period" and 5% "much more than before the confinement period").

Table 6. Discomfort caused by communal staircases and facilities.

	Airborne	Impact	Water	AC	Ext
Much less	8%	9%	6%	7%	7%
Some less	9%	8%	4%	5%	8%
The same	56%	59%	70%	77%	72%
Some more	19%	17%	16%	9%	10%
Much more	8%	7%	5%	2%	3%

The discomfort perceived from external traffic noise, heard inside the dwelling with the windows closed, was indeed affected compared to before the confinement, with 63% of the surveyed population reporting that they were less bothered by the noise than before: 24% reported "somewhat less than before the confinement period" and 39% reported "much less than before the confinement period".

However, the increase in displeasure caused by external noise from commercial premises such as garages, shops, bars, etc. was not as noticeable, since the majority of them remaining closed during the study period. Thus, only 36% of those surveyed perceived a lower incidence of these noises in their lives, with 56% of the population maintaining a similar level of discomfort as during the confinement period.

Table 7. Discomfort caused by commercial and traffic noise.

	Commercial	Traffic noise
Much less	23%	39%
Some less	13%	24%
The same	56%	27%
Some more	6%	6%
Much more	2%	4%

3.3 Comparison of satisfaction with home acoustic environment and importance of acoustic insulation before and during confinement

Participants were asked to express their level of satisfaction with the acoustic environment of their homes and the importance they give to acoustic insulation, as well as to define their sensitivity to noise. This section presents the results of the responses provided in relation to the two periods (before/during confinement). Tables 4 to 6 show the percentages of responses given for each of the options and the difference between both periods. The importance given to acoustic insulation (Table 8) hardly undergoes any modifications between the periods before and during confinement. The majority of respondents consider the acoustic insulation of their homes "Quite important" (47% before and 46% after) or "Very important" (26% before and 26% after).

Table 8. Importance of acoustic insulation. Comparison before and during confinement.

	Before	During	Difference
Not important	3 %	5%	2%
Some important	19%	17%	-2 %
NR	4%	6%	2%
Quite important	47%	46%	-1%
Very important	26%	26%	0%

The satisfaction of users with the acoustic environment of their home (Table 9) has changed compared to the period before the pandemic, with an increase of almost 7% in the number of people who express themselves as "Dissatisfied". The majority of participants consider themselves "Somewhat satisfied" with the acoustic environment of their home, with little variation between the before/after situations (48% and 46%, respectively). The percentage of people who feel "Quite satisfied" before the lockdown is also relevant, at 25%, with a 4% reduction during the lockdown period.

Table 9. Importance of acoustic conditions satisfaction. Comparison before and during confinement.

	Before	During	Difference
Dissatisfied	13%	20%	7%
Somewhat satisfied	48%	46%	-2%
NS/NC	6%	6%	0%
Quite satisfied	25%	21%	-4%
Very satisfied	8%	7%	-1%

Regarding noise sensitivity, it should be mentioned that approximately half of the participating population declare themselves as "Somewhat or not sensitive" to noise (52% before and 50% during confinement); there is even a 5% increase in people who describe themselves as "Not sensitive" during confinement compared to the previous situation. Approximately one-third of respondents have answered that they are "Quite sensitive" and 15% are "Very sensitive" to noise, with a 3% increase during confinement in those who consider themselves "Extremely sensitive."

Table 10. Noise sensitive.

	Before	During	Difference
Not sensitive	7 %	12%	5%
Somewhat sensitive	45%	38%	-7%
Quite sensitive	29%	28%	-1%
Very sensitive	15%	15%	0%
Extremely sensitive	3%	6%	3%

3.4 Importance of sound insulation, satisfaction with acoustic conditions, and noise sensitivity according to the date of housing construction.

The current building acoustic regulation is the DB HR [19], which came into effect in April 2009, updating the existing acoustic insulation requirements until then. However, the majority of the Spanish population still resides in buildings with low noise protection since they were constructed based on previous regulations or even before any acoustic regulation [20, 22, 23].

Taking this into account, and considering the available data collected through the questionnaire, it has been deemed interesting to analyze the user's responses regarding the importance of acoustic insulation, satisfaction with the acoustic conditions of the housing, and noise sensitivity according to the year of construction of the housing, attending to the periods "before 1988", "from 1988 to 2010", and "after 2010". The results are shown in figures 2 to 4.

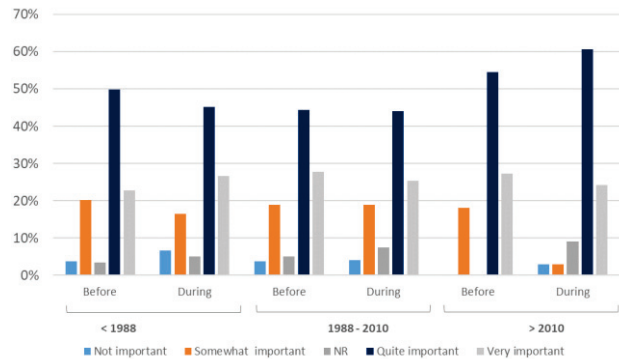


Figure 2. Sound insulation importance according to the construction year

According to Figure 2, and in line with the results of Table 8, it can be observed that the importance given to acoustic insulation has been considered "Quite or very important" throughout the three periods, with a clear increase in the importance given to acoustic insulation in those users of housing built after the year 2010.

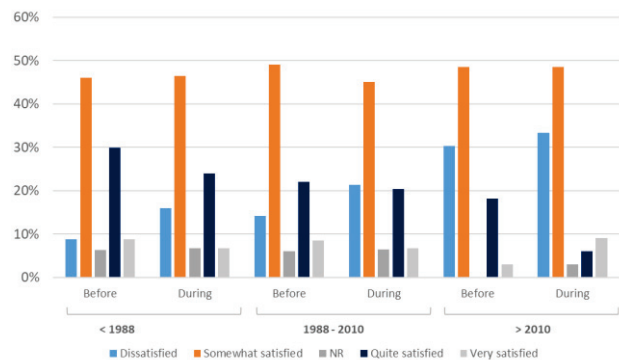


Figure 3. Satisfaction with acoustic conditions according to the construction year

Regarding satisfaction with the acoustic conditions of homes, there is a generalized trend of "Somewhat dissatisfied" as the majority response regardless of the construction period. There is an increase in the "Dissatisfied" population and a decrease in the "Quite satisfied" individuals over time, despite buildings having improved in acoustic quality according to the applicable regulations.

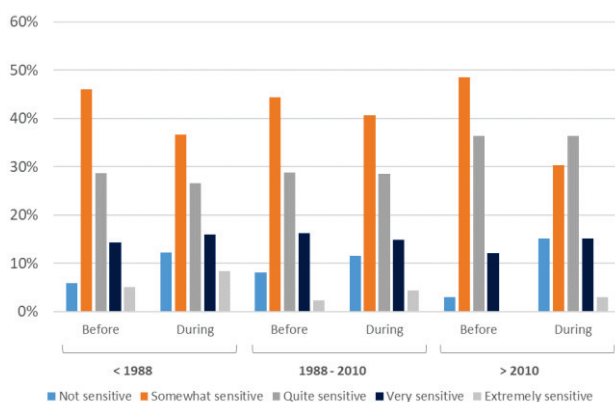


Figure 4. Sensitivity according to the construction year

The data does not show a clear trend in the evolution of noise sensitivity in relation to the date of construction of the housing. The responses remain practically homogeneous between the periods "before 1988" and "from 1988 to 2010". However, an increase is observed from 2010 in those who consider themselves "Quite sensitive".

4. CONCLUSIONS

The confinement resulting from the health crisis caused by Covid-19 forced the Spanish population to stay longer than usual in their homes, causing a change in habits that contributed to a general decrease in environmental noise levels, while neighbour noise increased, increasing the discomfort caused by it in homes.

This communication analyzes the sources of noise in buildings and the resulting discomfort, the importance of acoustic insulation for home users, their satisfaction with the acoustic conditions of their homes, and how they describe their sensitivity to noise.

The disturbance resulting from the most common noise sources in homes (general noise, noise produced by family members within the home, noise from neighbours, common stairs, and installations) has not undergone a significant increase compared to the period before confinement, with more than 50% of the surveyed population experiencing similar discomfort as before the pandemic in all of them. However, the discomfort caused by traffic noise has decreased, with only 10% of respondents feeling greater disturbance during the confinement period.

Regarding the importance that users give to acoustic insulation, there are no variations in the periods

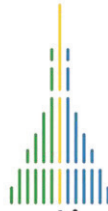
before/during confinement. It was already considered quite important before, with approximately 73% of respondents considering acoustic insulation "Quite or Very important," a trend that has been maintained over the years.

On the other hand, regarding satisfaction with the acoustic conditions of homes, although there are no significant variations, there is a decrease in satisfaction during confinement, in general terms.

Finally, in response to the question of how they would describe their sensitivity to noise, half of the participating population considers themselves "Somewhat or Not sensitive" and the other half "Quite, Very, or Extremely sensitive." Although there are no significant variations between the situations before/during confinement, there is some increase during confinement in those who define themselves as "Extremely sensitive."

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