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Roberto Alonso González-Lezcano,
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University of Žilina, Slovakia

*CORRESPONDENCE
Miguel Ángel Navas-Martín,
miguelangel.navas@pdi.atlanticomedio.es
Teresa Cuerdo-Vilches,
teresacuerdo@ietcc.csic.es

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Working from home and indoor environmental quality: a transdisciplinary questionnaire design based on a Delphi study

Miguel Ángel Navas-Martín[1,2]*, Pablo Meseguer Gancedo[3] and Teresa Cuerdo-Vilches[4]*

[1]National School of Public Health, Carlos III Health Institute (ISCIII), Madrid, Spain, [2]Faculty of Health Sciences, Mid-Atlantic University (UNAM), Las Palmas de Gran Canaria, Canary Islands, Spain, [3]Department of Sociology, Faculty of Political Sciences and Sociology, Complutense University of Madrid (UCM), Madrid, Spain, [4]Eduardo Torroja Institute for Construction Sciences (IETcc), Spanish National Research Council (CSIC), Madrid, Spain

Telework has grown significantly in recent decades, driven particularly by the COVID-19 pandemic, which sparked interest in analysing the conditions under which it takes place, as it had never before been so widespread in such many countries. However, most studies emerged in an exceptional context, without comprehensively or on a large scale addressing the environmental conditions of home-based teleworking under normal circumstances. This study aimed to identify and reach consensus, through an expert panel, on criteria for assessing such conditions in the home, as well as to analyse users' preferences, suitability, and satisfaction, by developing a robust questionnaire for its evaluation. A modified Delphi method was applied, involving two panels: specialists in the social sciences and in building sciences. Over four rounds, 18 social items and 59 construction-related items were gathered and refined, organised into four thematic blocks. Consensus was achieved through weighted scoring and the 75th percentile, resulting in a final questionnaire of 77 questions integrating both social and technical dimensions. For social science experts, variables such as educational level, occupation, and quality of digital devices were considered essential to understand the home teleworking experience. Experts in building physics and architecture prioritised general housing factors such as dwelling type, or tenure regime, whilst others resulted more specific, approaching IEQ, as lighting, thermal comfort, air quality, and acoustic insulation, besides ergonomics. The study also agreed on a definition of home-based teleworking, distinguishing it from other ways of remote work carried out in third-party locations—relevant, given that homes are not subject to the environmental regulations of traditional workplaces. Finally, and following data collection, the CHAMBER questionnaire yielded two validated constructs: Indoor Environmental Quality (IEQ), reflecting perceived comfort related to environmental conditions and control, and Physical Adequacy, assessing the suitability of the workspace's architectural and functional features. This dual approach differentiates experiential environmental quality from the structural adequateness of home-based teleworking settings. The questionnaire, either based on standards, official and nationwide surveys, and scientific literature, may be applied in other countries, contributing to future research and public policies aimed at improving the environmental quality of home-based teleworking, to integrate both human and physical environmental factors, for workers' health and wellbeing.

KEYWORDS

domestic, environment home, home office, IEQ, telecommuting, teleworking, workplace, workplace setting

1 Introduction

Teleworking has increased progressively over recent decades, although its most notable expansion occurred during the COVID-19 pandemic, when lockdown measures forced many organizations to adopt the remote model. According to the Global Survey of Working Arrangements, which in 2023 analyzed more than 40,000 workers across 34 countries, 25.6% of employees currently engage in hybrid arrangements, working from home at least 1 day a week, while 7.9% work entirely remotely (Shockley and Allen, 2024). This shift in working practices has brought multiple challenges, among them the need to adapt homes to accommodate functional and healthy work environments (Rotimi et al., 2024).

Although teleworking has been the subject of numerous studies, there is no universally accepted definition of the term (López-Igual and Rodríguez-Modroño, 2020). The literature employs various expressions to describe alternative forms of work organization, such as teleworking, remote work or working from home (Cuerdo-Vilches et al., 2021b), each carrying different nuances. In general, "teleworking" refers to any work activity carried out away from the usual workplace by means of information and communication technologies (ICTs), whereas "working-from-home" refers specifically to tasks performed in one's own residence, either partially or entirely (Lescarret et al., 2022). As teleworking has become more widespread as a mode of employment, new spatial categories have emerged to describe where it can be undertaken. For those who telework primarily, home has become the "first place" for performing work activities. The traditional office—where in-person work organized by the employer takes place—assumes the role of "second place" (Krauss and Tremblay, 2024). The concept of the "third place", introduced by Oldenburg (Oldenburg, 1989), refers to environments such as cafés, libraries, or community centres, which today also include coworking spaces (Lescarret et al., 2022). These locations offer a balance between productivity and socialization by enabling work outside the domestic setting. More recently, some authors have proposed the emergence of a "fourth place", represented by hybrid spaces that blur the boundaries between home, work, and social life—such as creative hubs and co-living arrangements (Morisson, 2017). These environments integrate residential, work, and social functions, reflecting the growing hybridization of personal and professional life in the era of teleworking (Krauss and Tremblay, 2024). In addition to these categories, some authors have drawn attention to the proliferation of what Marc Augé termed "non-places": spaces characterized by the absence of identity, history, and social relations, such as airports, stations, shopping centres, or underground carriages (Augé, 1993). Defined by their transient and anonymous nature, these settings contrast with Oldenburg's "anthropological places" in that they do not foster bonds or a sense of belonging. Although not originally conceived as workspaces, increasing digitalization has enabled many knowledge workers to use these transit spaces for brief work-related tasks (such as checking emails or connecting via mobile devices), highlighting a progressive detachment between work and physical location. This transformation—driven by ubiquitous connectivity and new ways of labour organization—illustrates how even spaces traditionally unrelated to the professional sphere can acquire new functions within the knowledge economy.

However, during the COVID-19 lockdown, the home was consolidated as the main (and in many cases the only) place for teleworking, exposing significant limitations in the configuration and suitability of dwellings. This adaptation process involved a reconfiguration of domestic spaces, which came to serve both home and work functions, often leading to overlapping uses that affected workers' comfort and productivity (Park et al., 2023). Within the project on social confinement, housing and habitability, [COVID-HAB] (Cuerdo-Vilches et al., 2020), carried out during the COVID-19 pandemic, more than one-third of Spanish domestic spaces intended for teleworking were found to be inadequate, with negative consequences for teleworkers' satisfaction and wellbeing. Among the results, it was notable that perceptions of the adequacy of the home workspace were strongly influenced by aspects of the architectural design of the dwelling, with natural lighting being one of the most valued elements, alongside thermal comfort, ventilation, furniture, and acoustic insulation (Navas-Martín et al., 2022). This perception of inadequacy was linked not only to the lack of exclusive rooms for working, but also to the environmental quality of such spaces. Among the most positively rated factors was natural lighting, present in more than half of the cases; however, this was generally concentrated in main areas of the home such as living or dining rooms, which were often shared with other household members or used for other purposes, thus hindering privacy and the performance of tasks requiring concentration or confidentiality. Other elements, such as noise insulation, ventilation, quality of furniture, and thermal comfort also played a relevant role in the overall assessment of the workspace (Cuerdo-Vilches et al., 2021a). Similar results were observed in Latin American contexts such as Mexico, where problems were reported in relation to thermal comfort, lighting, acoustic insulation, and the lack of exclusive spaces to work-from-home during lockdown (Jaimes Torres et al., 2021). The coexistence of multiple domestic activities during lockdown, together with the absence of prior planning for such environments, revealed the structural limitations of many dwellings in accommodating remote work satisfactorily (Cuerdo-Vilches et al., 2021a). The lack of dedicated workrooms, combined with the limited availability of adequate digital resources, emerged as key factors influencing perceptions of the suitability of the home environment for remote work, particularly during home confinement due to the SARS-CoV-2 outbreak. This structural deficit was exacerbated in households where several people had to telework or study simultaneously, leading to overcrowding of shared spaces. In many cases, the areas with the best natural lighting conditions (such as the living room or dining room) became the preferred locations for setting up a workstation, despite being areas of circulation or family interaction, which negatively affected acoustic insulation and privacy. Likewise, shortcomings in ergonomic furniture, limited ventilation, and a lack of control over the physical environment contributed to perceptions of discomfort and distraction, hindering job performance and increasing stress. Altogether, this showed that the adequacy of those settings depended not only on material factors, but also on the simultaneous use of rooms and the internal household organization during a prolonged lockdown period (Cuerdo-Vilches et al., 2021b). These difficulties affected not only physical comfort but also emotional wellbeing, revealing that household resilience and the emotional management of its occupants were key factors in coping with confinement (Navas-Martín and Cuerdo-Vilches, 2023).

In this context, the COVID-19 pandemic further consolidated the home as the primary place for teleworking, revealing important structural and environmental limitations in many dwellings. Institutional assessments conducted during the pandemic highlighted that, residential environments—often acting as the first line of protection for health—frequently lacked the spatial, environmental, and functional conditions required to adequately support professional activities on a sustained basis (Abellán García et al., 2021). These findings reinforced the need to address housing habitability not only from a social or organizational perspective, but also from an environmental and health-oriented approach.

Although numerous studies and investigations on teleworking have been carried out over time—both in terms of how it is implemented and its implications—to date no specific research has been conducted focusing on assessing the quality of those domestic spaces and their indoor environmental conditions associated, even more bearing in mind regular conditions, not in extreme ones, such as a pandemic. Despite the rapid expansion of teleworking, research explicitly addressing Indoor Environmental Quality (IEQ) in home-based workspaces is still scarce and fragmented. A recent scoping review identified a limited and weakly interconnected body of literature on the relationship between IEQ and working from home, with most studies concentrated in a small number of countries, often siloed and largely focused on exceptional contexts such as the COVID-19 pandemic rather than regular teleworking conditions (Navas-Martín et al., 2025).

This lack of comprehensive and standardized assessment tools highlights the need for integrative approaches capable of systematically evaluating the environmental adequacy of domestic teleworking spaces. The aim of this contribution is to present the results of the research process through which, using an adapted transdisciplinary Delphi Method, a questionnaire has been developed on the indoor environmental conditions of the home teleworking space, considering factors such as temperature, relative humidity, natural and artificial lighting, acoustic comfort, and indoor air quality—elements that have a significant impact on people's wellbeing. Furthermore, these environmental factors have been related to socio-demographic and economic variables, as well as to others linked to the participant' status as a teleworker, and general variables concerning housing conditions. To ensure the legitimacy of this questionnaire and given that it contains questions from both the sociological and the technical/architectural domains, only questions taken from official surveys, such as those of the Spanish National Statistics Institute (INE) have been used. For questions related to the technical aspects of housing, teleworking spaces and IEQ aspects, items were drawn from existing international standards or from those widely used in the relevant IEQ literature. Thus, it is the only existing questionnaire that comprehensively covers issues indoor environmental conditions (hygrothermal, acoustic, lighting, and indoor air) of the teleworking space, in regular conditions, as an integrated and detailed approach, as a final aim, and not as a means to analyze other aspects, such as conciliation, productivity, or workers' mental health.

This questionnaire is part of a research project, also supported for two additional ones, indicated in Funding section. While this project envisaged its application at the national level in Spain, the questionnaire could be applied to any other geographical region where this mode of work takes place. The support by international projects, such as one of the additional referred in Funding section, aims to ease its implementation in other contexts and regions worldwide.

2 Methods

2.1 The Delphi method

The Delphi method is a structured research technique based on conducting multiple rounds of consultation with a panel of experts, aimed to reach consensus on specific issues. Despite the Delphi technique could have different purposes, usually the progressive collective work on the subject conducts to a refinement, for a specific round, in which participants are provided with an aggregated summary of the group's responses. It enables each of the experts to reconsider their position, taking into consideration the collective opinion. This iterative process seeks not only the convergence of views but also stability in the responses, thereby reducing potential interference arising from irrelevant or biased communications (Sobaih et al., 2012; von der Gracht, 2012).

This technique has been widely employed in fields such as medicine, public health, and education, where it facilitates the gathering of informed expert judgements on complex issues, thereby supporting decisions grounded in specialised knowledge (Mahajan et al., 1976; Gupta and Clarke, 1996; Thangaratinam and Redman, 2005; Fathullah et al., 2023; Brush et al., 2024). It has also found an increasing use in the field of architecture, both for establishing research priorities and for developing environmental assessment systems adapted to different contexts. For instance, it has been applied to define an international research agenda in landscape architecture (Meijering et al., 2015), as well as to assess the environmental performance of buildings using tools focused on indoor environmental quality (IEQ), encompassing variables such as ventilation, lighting, acoustics, and temperature, with particular attention to occupants' wellbeing and health (Qi et al., 2011; Keyvanfar et al., 2014; Kamaruzzaman et al., 2019; Yuan et al., 2021).

In this regard, the Delphi method has been adapted in different contexts to overcome its practical limitations. These modifications have enabled more precise selection of experts, a reduction in dropout rates, and an improvement in the quality of results, resulting the process in a more agile, flexible, and suitable tool for application in new settings (Sobaih et al., 2012; von der Gracht, 2012). For this reason, the present research employed a modified Delphi to reach expert consensus in the development of a questionnaire on work-from-home settings and indoor environmental quality. The modified Delphi represents a simplified version of the original design, allowing time savings and enabling experts to focus specifically on the study subject (Information Resources Management Association, 2021). Moreover, previous research has shown that it can result more efficient than the classical model (Gustafson et al., 1973; Graefe and Armstrong, 2011). Thanks to its versatility, the modified Delphi has been successfully applied in different fields of knowledge (Egfjord and Sund, 2020; Ko and Lu, 2020; Basinska et al., 2021; Valerino-Perea et al., 2021). For this study, a modified Delphi approach was employed to develop the final version of the questionnaire. Figure 1 presents a schematic overview of the different rounds leading to the final instrument.

2.2 Participants

To undertake the taxonomization of the indoor environmental conditions of teleworking spaces within homes, it was necessary to include, in the construction of the questionnaire, aspects related to the sociodemographic and economic realities of the participants, as well as from the household unit, primarily, alongside an understanding of issues related to the teleworking condition itself. Questions relating to those aspects were to be addressed by experts in sociology and statistics. Similarly, to define the indoor environmental quality of the domestic teleworking space, and the dwelling in general, experts in building physics and IEQ were consulted, such as engineers and architects specialized in hygrothermal, acoustics, lighting, indoor air comfort, as well as ergonomics.

The expert panel consisted of two groups. On one hand, ten experts in the field of building science, of whom three were men and seven women. On the other, ten experts in the social sciences (sociology and statistics), composed by four women and six men. Thus, the panel was gender-balanced. Furthermore, the selection of participants was based on criteria of proven experience in areas related to the built environment, indoor environmental quality, and teleworking. The experts were recruited by convenience sampling, thereby ensuring the suitability, transdisciplinary expertise and diversity required for the panel.

Table 1 presents a summary of the profiles of the researchers involved in the construction of the questionnaire, differentiated by field of expertise.

All information reported in Table 1 is presented in aggregated form and does not allow identification of individual experts.

2.3 Questionnaire development

For the questionnaire design, several rounds were conducted (Figures 1, 2): a first round aimed at collecting potential questions to include in the questionnaire, taking into account the required fields and items to be included; a second round for refinement and decision-making; a third round for final prioritization; and a fourth and final round for individual review and final consensus.

The collection of questions in the first round was carried out via email, and the information was organized in an Excel spreadsheet. For the subsequent phases, a specific online questionnaire was used for each group of experts, presenting the list of questions along with their corresponding codes for prioritization and selection. The questions were displayed in a random order to reduce potential selection biases. Participants were asked to rank the questions by placing the most important ones at the top and the least relevant at the bottom. Microsoft Forms from Office 365 was used to create these online questionnaires.

2.3.1 First round: item generation

In the first round, panel members were asked to openly submit proposed questions that, from their respective fields of expertise, they considered essential for evaluating the quality of the indoor environment in domestic teleworking spaces. In the Delphi methodology, the initial rounds are precisely designed to generate ideas or items, encouraging a broad collection of initial contributions (Keeney et al., 2010).

The invitation message encouraged each proposal to be accompanied, whenever possible, by the references of the original sources where they were taken from, either a standard, an official survey, or scientific literature (for example, ISO standards, INE surveys, etc.). Participants were also given the option to include open suggestions if they could not find a specific reference, as well as additional considerations regarding the wording of the questions, the different categories to be considered as responses, or nuances related to the particular focus of this questionnaire under development, always providing a justified observation within the Excel spreadsheet.

This stage allowed for a broad collection of questions, which were later classified into four thematic blocks: 1) sociodemographic and economic information, 2) general housing features, indoor environmental quality, 3) characteristics and perception on telework experience, and 4) indoor environmental conditions within the domestic work-from-home space. Among the proposed items, the need to establish a clear and operational definition of working-from-home stood out, serving as a common framework for formulating the remaining questions. For its development, the definitions of remote work and teleworking set out in Article 2 of Law 10/2021, of July 9 (Gobierno, 2021), were taken as a reference. The proposed definition was subsequently reviewed and refined once consensus was reached in the subsequent rounds.

2.3.2 Second round: initial refinement and decision-making

In the second round, the collected questions were organized and sent back to the experts, who were asked to evaluate them and decide on their initial inclusion or exclusion, especially in cases of repetitions or similarities between more than one question within each thematic block. Each expert ranked the questions from most to least relevant (Sobaih et al., 2012). Thus, this round allowed for an initial refinement, eliminating redundancies and low-priority questions, whilst others could emerge once detected a lack of focus or a different detail approach according to each block, consolidating the first structure of the questionnaire.

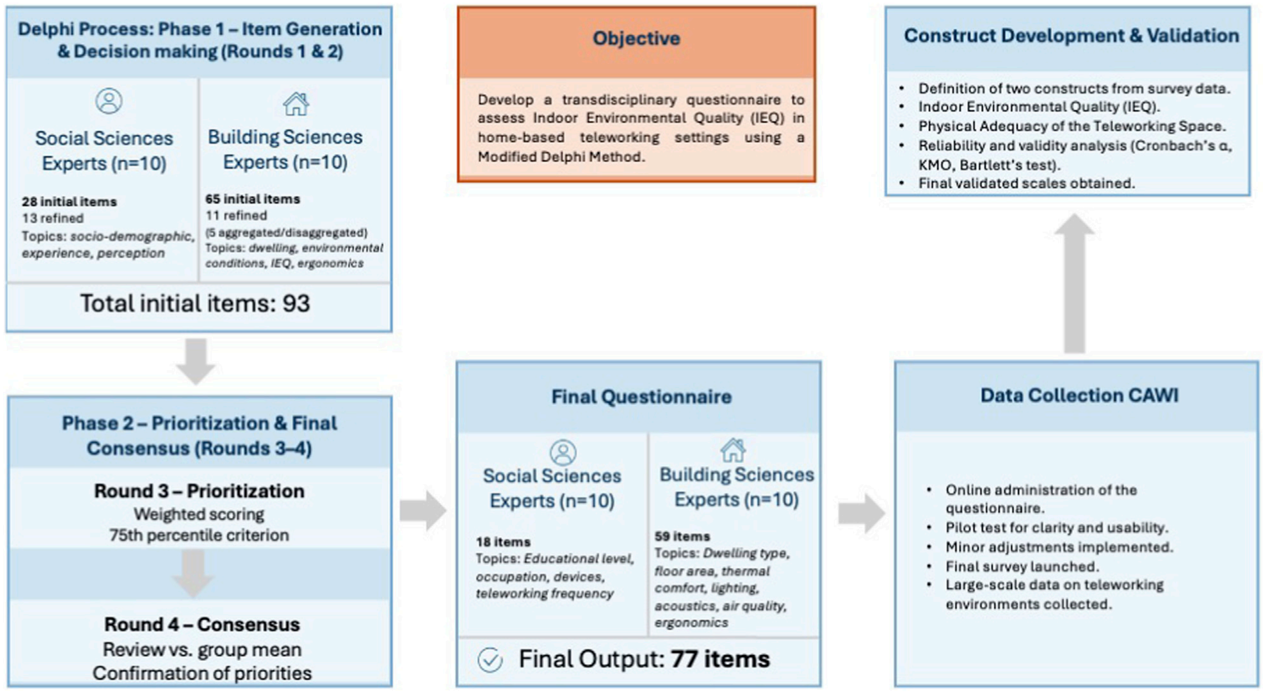

FIGURE 1
Graphical abstract of the Delphi process to deliver the final questionnaire.

2.3.3 Third round: prioritization

During the third round, after a balanced analysis of the second-round responses, panelists were asked to review again the thematic blocks containing the highest-rated questions and to prioritize them to further refine the proposed items. This phase employed ranking and weighting techniques, aiming to bring expert opinions closer together through group feedback based on preliminary statistical results (means, medians, standard deviations). The prioritization achieved served to further fine-tune the items that would make up the final questionnaire.

2.3.4 Fourth round: individual review and final consensus

In the fourth round, each expert received a personalized report where they could compare their previous individual responses with the average responses of their expert group. They were given the opportunity to either maintain their original ratings or modify them considering the group results, following the Delphi principle of reflection and progressive adjustment (Keeney et al., 2010; Linstone and Turoff 1975; Skulmoski et al., 2007). This strategy increased the level of consensus and allowed for the final tailoring of the questionnaire.

2.4 Data collection

Data collection was conducted using a Computer-Assisted Web Interviewing (CAWI) platform. CAWI is a digital survey methodology that enables the online administration of structured questionnaires, allowing respondents to complete the survey remotely through a web interface. In this study, the CAWI platform was used to adapt the CHAMBER questionnaire to an online format, conduct a pilot test to assess functionality and comprehension, and subsequently implement the large-scale data collection.

2.5 Data analysis

During the question prioritization process, a weighted score was assigned to each item based on its position within the ranking and the frequency of selection by the experts. The top-ranked item received the highest score, decreasing progressively to assign the lowest score to the last place. Subsequently, the total score obtained by each item was divided by the total number of participants, thus obtaining an average score.

To do this, descending scores were assigned from the total number of prioritised items (n_{max}) down to 1, according to their position in each expert's individual ranking. That is, the item in first place received n_{max} points, the second $n_{max} - 1$, and so on, down to 1 point for the last item. The total score for each item was calculated according to the following formula:

$$\sum_{i=1}^{n_{max}} n_i \cdot (n_{max} - i + 1)$$

As a consensus criterion, items whose values fell within the 75th percentile were considered (Lozano-Cabedo et al., 2025; Vio et al., 2020). This approach allowed a robust identification of priority items for both the social-sciences expert group and for the building-sciences one.

TABLE 1 Profiles of the experts participating in the modified Delphi process.

Gender	Age	Professional profile	Speciality
Field: architecture and building engineering			
F	35–44	PhD architect	Hygrothermal comfort/Energy
F	35–44	PhD engineer	Indoor air quality/Health
F	55+	PhD architect	Indoor air quality/Health
F	45–54	PhD architect	Lighting/Ergonomics-Accessibility
M	45–54	PhD architect	Lighting/Ergonomics-Accessibility
F	45–54	PhD architect	Acoustic comfort
F	35–44	Technical engineer	Acoustic comfort
M	55+	PhD architect	Sustainability/Lighting/Ergonomics
F	45–54	Engineer	Acoustic comfort
M	55+	PhD architect	Hygrothermal comfort/Energy
Field: sociology and statistics			
M	45–54	PhD sociologist	Sociology of professions and health
M	45–54	PhD in biomedical sciences and public health	Urban environment/Digital teleworking/Environmental health
F	35–44	PhD sociologist	Urban sociology/Housing/Ageing
F	45–54	PhD anthropologist	Urban sociology/Housing/Ageing
M	35–44	PhD sociologist	Employment, society and territory/Policy and internationalisation
F	45–54	Statistician	Evaluation of quantitative methods
M	45–54	Sociologist	Social research processes
F	35–44	Sociologist	Urban sociology
M	45–54	PhD sociologist	Sociology of work
M	45–54	PhD sociologist	Sociology of work

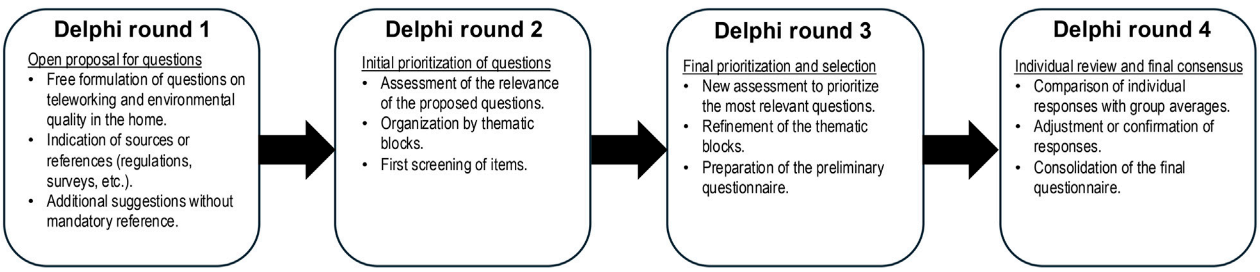

FIGURE 2
Summary of the Delphi rounds.

2.6 Development and operationalization of IEQ-related constructs

The CHAMBER questionnaire constitutes the final outcome of the modified Delphi process described in this study. It was designed as a comprehensive instrument to assess indoor environmental conditions and the physical adequacy of home-based teleworking spaces under regular, non-crisis circumstances. The questionnaire integrates items related to indoor environmental quality, housing characteristics, workspace conditions, and contextual social variables.

Although the questionnaire includes a larger number of technically oriented items, this distribution reflects the core objective of the instrument: the assessment of indoor environmental conditions and habitability. Social and sociodemographic variables are incorporated as contextual factors that enable the interpretation of environmental exposure, perception, and adaptive capacity. Rather than functioning

TABLE 2 Constructs derived from the CHAMBER questionnaire for the assessment of home-based teleworking environments.

Construct	Variable code	Item description	Conceptual domain
Indoor environmental quality (IEQ)	p280000	Thermal sensation in summer	Thermal comfort
	p290000	Thermal sensation in winter	Thermal comfort
	p340000	Perceived draught discomfort	Thermal comfort
	p320000	Frequency of heating use	Environmental control
	p330000	Frequency of cooling use	Environmental control
	v350000	Annoyance from indoor noise sources	Acoustic comfort
	v360000	Annoyance from outdoor noise sources	Acoustic comfort
	v370100	Satisfaction with acoustic environment	Acoustic comfort
	v370200	Satisfaction with overall noise level	Acoustic comfort
	p380000	Perceived air quality in the workspace	Air quality
	p390000	Type of ventilation system	Air quality
	p400000	Frequency of natural ventilation	Air quality
	v410100	Satisfaction with natural lighting	Visual comfort
	v410200	Satisfaction with artificial lighting	Visual comfort
	v410300	Satisfaction with overall lighting	Visual comfort
	v420100	Presence of glare	Visual discomfort
	v420200	Visual fatigue	Visual discomfort
	v420300	Difficulty reading due to lighting	Visual discomfort
	p430100	Use of devices to reduce daylight (shading)	Environmental control
	p430200	Use of artificial lighting during daytime	Environmental control
Physical adequacy of the teleworking space	p250100	Room size	Spatial adequacy
	p250200	Thermal conditions of the room	Environmental adequacy
	p250300	Natural light availability	Visual adequacy
	p250400	Artificial lighting conditions	Visual adequacy
	p250500	Acoustic insulation	Acoustic adequacy
	p250600	Visual connection with the exterior	Biophilic/visual quality
	p250700	Windows and carpentry	Architectural quality
	p250800	Solar control devices	Architectural quality
	p250900	Surface finishes	Architectural quality
	p251000	Furniture adequacy	Ergonomic adequacy
	p251100	Storage capacity	Functional adequacy
	p251200	Presence of vegetation	Biophilic quality

as an independent analytical dimension, these variables provide the necessary framework to understand how personal and professional circumstances influence perceptions of Indoor Environmental Quality (IEQ) and the Physical Adequacy of the Teleworking Space.

Once the CHAMBER questionnaire was established and refined, two independent constructs related to the specific features of the teleworking environment were defined and operationalized: Indoor Environmental Quality (IEQ) and Physical Adequacy of the Teleworking Space. These constructs were derived from specific blocks of the questionnaire and represent two complementary yet conceptually distinct dimensions of the home-based work setting (Table 2).

The Indoor Environmental Quality (IEQ) construct was conceptualized as a multidimensional measure of users' subjective perception of environmental conditions within the teleworking space. It was operationalized through a 20-item scale integrating variables related to thermal comfort, acoustic environment, air quality and ventilation, visual comfort, as well as environmental

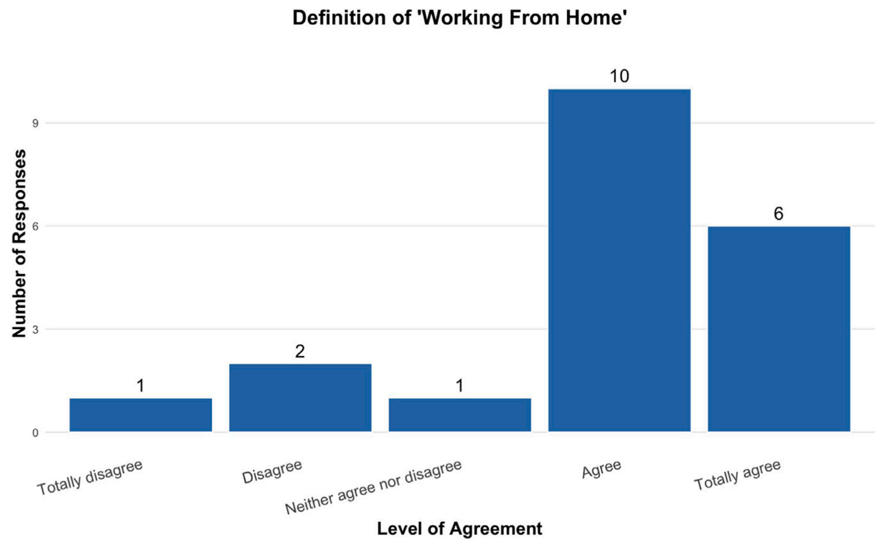

FIGURE 3
Level of agreement with the definition of working-from-home.

control and adaptive behaviours (e.g., frequency of heating and cooling use, use of shading devices and artificial lighting during daytime). These items capture both experiential responses to indoor environmental conditions and the strategies adopted by users to regulate and adapt to those conditions in everyday teleworking practice.

The Physical Adequacy of the Teleworking Space construct was derived from the matrix question P250000 ("How would you rate the following aspects of the space in which you usually telework?"). This scale comprises 12 items (P250100–P251200) assessing the perceived adequacy of architectural, spatial and functional characteristics of the workspace, including room size, thermal and lighting conditions, acoustic insulation, surface finishes, furniture, storage capacity, visual connection with the exterior and presence of vegetation. Responses were collected using a three-point ordinal scale (1 = good/adequate, 2 = indifferent, 3 = needs improvement), providing a global evaluation of the suitability of the physical configuration of the workspace for teleworking purposes.

The psychometric properties of both constructs were subsequently evaluated through reliability and construct validity analyses, including Cronbach's alpha, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, in order to assess their internal consistency and suitability for factorial analysis.

3 Results

3.1 Results from the Delphi process

In the first round, a total of 28 questions related to sociodemographic characteristics, experience, and perceptions of teleworking were received from the group of experts in the social sciences field. Likewise, 65 questions were collected from the experts in the building science field, focusing on general household characteristics, environmental conditions, work-from-home space, and ergonomics.

In the second round, experts were asked to select, from several alternative formulations, those questions they considered most appropriate within each thematic block. The objective of this phase was to refine the questionnaire by eliminating redundancies and improving the relevance and clarity of the items. In the case of the social sciences expert group, 13 out of the initial 28 questions were reviewed due to doubts about their wording or content. Meanwhile, the building science expert group evaluated 11 of the original 65 questions that raised concerns about their formulation. Of these 11 questions, 5 required further consideration to decide whether their content should be aggregated or disaggregated. Additionally, both expert groups were offered the opportunity to respond to an open-ended question to include further comments or suggestions.

In the third round, prioritization of all collected questions was facilitated, allowing experts to have a comprehensive view of the proposed items and to decide, based on their expert judgment, which should be considered priorities and which could be omitted. The social sciences expert group prioritised a total of 18 questions, distributed across three thematic blocks: demographic and economic data of the household, teleworking experience and perception (I), and teleworking experience and perception (II). The first experience block (I) covered general aspects of telework use, frequency, and conditions during the reference period, while the second block (II) delved into the subjective evaluation of telework, including aspects such as personal satisfaction, difficulties encountered, and impact on work-life balance. The building sciences expert group prioritised 59 questions, organised into nine thematic sections, addressing various dimensions of the physical telework environment. These sections included general household characteristics, environmental conditions, workspace features, and IEQ features, related to thermal comfort, indoor air quality, acoustic insulation and lighting comfort (divided into technical functionality and sensory perceptions), and ergonomics.

Regarding the definition of working from home, 80% of the experts agreed (n = 10) or strongly agreed (n = 6) with the proposed formulation (see Figure 3). Based on the consensus reached, the following definition was established: "Working from home is remote

TABLE 3 Average score of the items prioritized by the panel of experts in the field of social sciences in rounds 4 and 5.

Household demographic and economic data	Round 3	Round 4
What is the highest level of education you have completed?	7,4	7,7
Could you tell me your current occupation?	6,8	6,8
How many people live in the dwelling, including yourself? Please specify the number of people in each age group	5,8	6,1
What is the activity of the establishment, institution, or company you work for?	5,4	4,9
In your main job, which of the following best describes your employment status?	5,2	4,7
What type of working hours do you have in your job — full-time or part-time?	4,5	4,6
Please indicate your household's net monthly income	4,3	4,3
Is your employment contract or working arrangement permanent or temporary?	2,9	3,2
If you have any type of disability, please indicate what type it is and whether it is temporary or permanent	2,7	2,7
Experience and perception of telework I	**Round 3**	**Round 4**
In general, what percentage of your working hours do you usually perform in teleworking mode?	3,9	4,4
How would you rate your experience with teleworking?	3,7	3,5
For how long have you regularly worked from home?	3,5	3,3
If you could choose, what percentage of your current working hours would you like to spend teleworking?	2,4	2,6
Do you think teleworking requires more effort and dedication from workers than on-site work, or less effort and dedication?	2	1,2
Experience and perception of telework II	**Round 3**	**Round 4**
Rate the digital resources (equipment, devices, etc.) you have available to telework from home	2,1	3,3
How many people in your household work from home?	1,8	3
Please indicate what type of expense compensation or reimbursement your company has provided or provides for working from home (select all that apply)	1,7	2
Has your company provided you, at a reduced cost or free of charge, any housing-related services such as gas, electricity, water, landline, or mobile phone bills?	1,7	1,7

work carried out from the worker's residence through the predominant use of computer and telecommunication means and systems."

However, comments were received regarding the differences between the terms "remote" and "from the home." In this context, the objective of the study was to define teleworking specifically as work carried out from the usual residence, distinguishing it both from the second place (the office) and the third place (other spaces such as hotels, cafés, or coworking spaces). This distinction is essential since the focus of the study is to analyse the environmental conditions specific to the home, considered a private space, as opposed to other environments subject to specific regulations. Likewise, the expression "working from home" was preferred over "remote working," given that the latter term could encompass other locations besides the home, that has to be also consider as a regular workspace, that is the main difference with third locations, that could result itinerant, and thus, different each time. Regarding the use of computer resources, it was decided to simplify the definition by explicitly including this reference, following the experts' recommendations. In this way, the study was limited to those teleworking modalities carried out from the home using digital resources, leaving open the possibility of exploring broader forms of teleworking in future research.

In the fourth and final round, each expert was provided with an individual answer book containing the group results from the third round, along with descriptive statistics values (mean, median, standard deviation, and quartiles). They were offered the opportunity to compare their individual response with the group mean value to, if appropriate, modify their assessment. If they made a change, the experts were required to justify it. However, if they decided to maintain their previous response, they did not need to complete the questionnaire again at this stage.

In this round, four experts from the field of social sciences reported changes to their responses, while two building experts made modifications. Once these adjustments had been incorporated, the consolidated results were sent again to all participants, giving them the option to make further changes. However, all experts confirmed their acceptance of the final outcome, thereby validating the definitive prioritization of the questions to be included in the final questionnaire. Below, the table shows the results of the prioritization carried out by the social sciences experts (Table 3) and the building science experts (Table 4) in their final rounds.

TABLE 4 Average score of the items prioritized by the panel of experts in the field of building sciences in rounds 4 and 5.

Item	General characteristics of the household	Round 3	Round 4
23	Select the type of dwelling you live in	7,5	7,5
27	What is the approximate usable floor area of the dwelling?	6,9	7,1
29	Condition of the building	5,9	5,9
28	Year of construction of the building	5,7	5,7
25	Does your home have any element or space connected to the outdoors?	5,4	5,2
36	How would you describe the main heating system in your home?	4,1	4,1
24	Regarding your surroundings, how is your home?	3,3	3,3
26	Tenure status of the dwelling	3,1	3,1
37	How would you describe the main air conditioning (cooling) system in your home?	3,1	3,1
Item	**Environmental conditions of the household**	**Round 3**	**Round 4**
31	How would you generally describe the amount of natural light entering your home?	5,1	5,1
35	Regarding cold insulation in general, how do you find your home?	3,7	3,7
33	Regarding noise insulation in general, how do you find your home?	3,7	3,6
34	Regarding heat insulation in general, how do you find your home?	3,6	3,6
30	How would you generally rate the indoor air quality in your home?	3,5	3,5
32	How would you generally describe the artificial lighting in your home?	1,4	1,5
Item	**Teleworking space: general criteria**	**Round 3**	**Round 4**
38	Do you have a regular space to telework in your home?	5,9	5,9
40	Please indicate which of the following aspects of your workspace you consider good or adequate	3,7	3,7
42	What was the main criterion for choosing your teleworking space in your home?	3,4	3,7
43	Please indicate which aspects of your teleworking space you would improve	3,4	3,1
41	Considering all the previous aspects, how do you consider the space where you telework?	2,5	2,5
39	Regarding your surroundings, how is your teleworking space?	2,1	2,1
Item	**Environmental quality of the teleworking space: (hydro)thermal comfort**	**Round 3**	**Round 4**
45	How do you rate the thermal comfort in your teleworking space during winter?	8,2	8,2
44	How do you rate the thermal comfort in your teleworking space during summer?	7,4	7,2
48	How often do you use heating devices in winter in your teleworking space?	6,8	6,8
46	What type of heating does your teleworking space have?	6,2	6,2
47	What type of cooling does your teleworking space have?	5,8	5,8
49	How often do you use cooling devices in summer in your teleworking space?	5,6	5,6
50	In your workspace, do you suffer from any drafts that you find uncomfortable?	4,6	4,6
51	Is there any enclosure in your workspace that you find particularly cold or hot?	3,7	3,7
53	In summer, do you require more or less clothing in your workspace than usual?	3,7	3,7
52	In winter, in your workspace	3	3
Item	**Environmental quality: noise insulation and acoustic comfort**	**Round 3**	**Round 4**
57	Considering the last 12 months, how satisfied are you with the acoustic environment of your teleworking space?	4,3	4,3

(Continued on following page)

TABLE 4 (*Continued*) Average score of the items prioritized by the panel of experts in the field of building sciences in rounds 4 and 5.

Item	Environmental quality: noise insulation and acoustic comfort	Round 3	Round 4
55	Considering the last 12 months, to what extent does noise from indoor sources (neighbours, installations, etc.) bother or disturb you in your teleworking space?	3,8	3,8
58	What is your overall satisfaction with the noise level in your work environment?	3,7	3,7
56	Considering the last 12 months, to what extent does noise from external sources (traffic, leisure activities, etc.) bother or disturb you in your teleworking space?	3,5	3,5
54	How do you rate the noise insulation in your teleworking space?	2,9	2,9
59	What is the main source of noise present during your teleworking activity?	2,8	2,8
Item	**Environmental quality of the teleworking space: indoor air quality**	**Round 3**	**Round 4**
60	How do you generally rate the air quality in this space?	4,5	4,5
63	Regarding natural ventilation, how frequently do you generally open and close the windows in your teleworking space?	3,5	3,5
61	Do you have any mechanical ventilation system in your teleworking room? If yes	2,8	2,8
62	Do you ventilate the teleworking space by opening a window to the outside? Please select the answer that best fits your situation	2,5	2,5
64	How do you keep the door that separates the workroom from the rest of the home?	1,7	1,7
Item	**Functionality and technical characteristics of lighting**	**Round 3**	**Round 4**
78	Do you use artificial light to work during daylight hours?	4,5	4,5
76	Does your workspace have sufficient general lighting?	4,7	4,4
77	When working, do you use any device to filter natural light, such as curtains, blinds or shades?	3,3	3,6
75	Is it possible to see the sky from your workstation?	3,2	3,2
73	Is the lighting positioned to prevent glare and reflections?	2,7	2,7
74	Is there a lot of visual contrast on your computer screen or work desk?	2,6	2,6
Item	**Lighting sensations and perception**	**Round 3**	**Round 4**
65	How do you generally rate the natural light in this space?	7,3	7,3
67	What is your overall satisfaction with the amount of lighting?	6,3	6,3
66	How do you generally rate the artificial lighting in this space?	5,6	5,6
69	Evaluate your ability to read and/or carry out tasks due to the lighting	5,2	5,2
70	Evaluate your level of visual fatigue due to the room's lighting	3,6	3,6
68	What is the general level of glare caused by the lighting?	3,3	3,3
71	What is your overall satisfaction with colour perception?	2,6	2,6
Item	**Ergonomics**	**Round 3**	**Round 4**
79	In general, do you have enough space to vary the position of your legs and arms?	6,8	6,8
81	At the end of the working day, is the tiredness you feel considered normal?	3,2	3,2
80	In general, do you have enough space to work comfortably?	1,5	1,5

Following the successive Delphi rounds, efforts were made to balance, as far as possible, the number of questions in the questionnaire so that no areas of the indoor environment conditions of the teleworking space were more extensively defined than others. Scales and response categories were also standardized across analogous questions addressing different aspects of environmental comfort. Finally, the questionnaire was adapted to the CAWI digital platform in order to systematize the process and avoid potential dropouts and low response rates, which could otherwise prolong data collection until the representative sample was reached according to the established quotas.

3.2 Results for the validation of the constructs

The Indoor Environmental Quality (IEQ) construct was initially operationalized as a 20-item scale encompassing both perceptual and behavioural dimensions of the indoor environment. The scale integrated variables related to thermal, acoustic and visual comfort, air quality, as well as environmental control and adaptive behaviours (e.g., frequency of heating and cooling use, use of devices to reduce daylight, and use of artificial lighting during daytime). This IEQ scale demonstrated acceptable internal consistency (Cronbach's α = 0.736) and satisfactory sampling adequacy (KMO = 0.76), with Bartlett's test confirming the suitability of the data for factor analysis (χ^2 = 8357.09; df = 190; $p < 0.001$). However, exploratory factor analysis revealed a less coherent structure, with several items related to adaptive control behaviours showing weak item-total correlations and limited factorial integration. These results indicate that although the scale captures a broad representation of indoor environmental conditions, the inclusion of behavioural control variables introduces conceptual heterogeneity, supporting the distinction between perceptual environmental quality and adaptive strategies implemented by users.

The second construct, the Physical Adequacy of the Teleworking Space, was defined using 12 items evaluating the perceived suitability of the architectural, functional and ergonomic characteristics of the home-based workspace (P250100–P251200). This scale assesses aspects such as room size, thermal and lighting conditions, acoustic insulation, surface finishes, furniture, storage capacity, visual connection with the exterior and presence of vegetation, reflecting a global appraisal of the structural appropriateness of the teleworking setting. The construct demonstrated high internal consistency (Cronbach's α = 0.882) and excellent sampling adequacy (KMO = 0.92), with Bartlett's test indicating strong suitability for factor analysis (χ^2 = 3738.55; df = 66; $p < 0.001$). These results confirm a robust and coherent internal structure, supporting the validity of this scale as an independent measure of the perceived adequacy of the physical configuration of the teleworking environment, distinct from the subjective perception of environmental comfort.

4 Discussion

The process of developing the questionnaire to be used for the CHAMBER research project achieved a high level of consensus among experts regarding the elements to be considered for assessing the environmental conditions required for home-based teleworking, initially designed for the Spanish context. Through the Delphi process, a total of 18 items in the field of social sciences and 59 items in the field of building sciences were collected, prioritized, and refined, organized into four thematic blocks related to the socioeconomic teleworker's conditions (I) and work-from-home experience (II), dwelling conditions (III), and workspace (IV), paying attention to the environmental quality conditions.

In the case of the social sciences expert group, the prioritized questions focused on sociodemographic aspects and technological resources for teleworking, considered key contextual elements for interpreting the home's environmental conditions. Particular emphasis was placed on the importance of identifying the highest educational level attained (item 6) and current occupation (item 7) as variables influencing the capacity to work from home. Likewise, the proportion of the working day carried out in teleworking mode (item 15) and the evaluation of the quality of the digital resources available at home (item 19) were prioritized. These results provide a better understanding of how personal circumstances and technological resources shape, facilitate, or limit the teleworking experience, but should be understood as complementary variables to the analysis of indoor environmental conditions, which form the central focus of the present study.

The results obtained for the social sciences expert group are consistent with previous literature on teleworking. Various studies have indicated that factors such as educational level and current occupation significantly influence the ability to adapt to remote work (Allen et al., 2015; Messenger and Gschwind, 2016). A higher level of education is generally associated with better digital skills and greater work autonomy, two conditions considered key for effective teleworking. Similarly, the proportion of the working day spent teleworking has been linked in earlier research to perceptions of efficacy, wellbeing, and productivity (Eurofound et al., 2017). The quality of the digital resources available at home has also been identified as an essential determinant in the teleworking experience, both in terms of performance and satisfaction (Felstead and Henseke, 2017). Therefore, the results of the present study not only align with previous findings but also reinforce the importance of considering sociodemographic and technological variables in the design of effective teleworking policies.

Regarding the items prioritized by the experts in the field of building sciences, fundamental aspects highlighted included the type of dwelling and its usable floor area (items 23 and 27), as well as the availability of a dedicated space regularly used for teleworking (item 38). High scores were also assigned to the quality of daylighting in the home (item 31) and in the workspace (items 65 and 67), alongside satisfaction with artificial lighting (item 66) and overall lighting (items 78 and 76). Thermal comfort, both in winter and summer (items 45 and 44), the acoustic environment (item 57), indoor air quality (item 60), and the ergonomics of the workspace (item 79) completed the set of environmental conditions deemed priorities. These results highlight that fundamental environment factors—lighting, temperature, air quality, acoustics, and physical space—are perceived as essential to ensure an adequate teleworking environment at home.

The results prioritized by the experts in building sciences show remarkable consistency with the existing literature on teleworking and the quality of the built environment. Several studies have emphasized the importance of housing characteristics, such as building type and available usable floor area, in shaping teleworkers' perceptions of comfort and productivity (Awada et al., 2021; Cuerdo-Vilches, Navas-Martín, and Oteiza, 2021; de Klerk et al., 2021; López-Igual and Rodríguez-Modroño, 2020; Nguyen et al., 2020). Likewise, the availability of a dedicated workspace has been linked to significant improvements in subjective wellbeing and work efficiency. Regarding environmental conditions, daylighting quality, thermal comfort, and indoor air quality are recognized as key determinants of environmental satisfaction in teleworking spaces (Awada et al., 2021; Cuerdo-Vilches, Navas-Martín, and Oteiza, 2021). Additionally, the presence of an adequate acoustic environment has been directly associated with reduced levels of distraction and mental fatigue (Awada et al., 2021; Casla-Herguedas et al., 2023), critical factors for maintaining performance and psychological wellbeing. Finally, the emphasis placed on the ergonomics of workspaces reinforces previous findings indicating that having ergonomically suitable furniture and equipment helps reduce the risk of musculoskeletal disorders and improves job satisfaction (Awada et al., 2021; Moretti et al., 2020).

Regarding the validation of the questionnaire through the two constructs, the differentiation between Indoor Environmental Quality (IEQ) and Physical Adequacy of the Teleworking Space provides relevant theoretical and methodological insight into the assessment of home-based teleworking environments. While both constructs address environmental conditions, their distinct psychometric behaviour confirms that users distinguish between the experiential perception of comfort (temperature, noise, light and air) and the structural suitability of the physical workspace configuration (layout, furniture, finishes or spatial organization). This separation reinforces the need to avoid treating the home teleworking environment as a single homogeneous variable, supporting instead a multidimensional perspective that differentiates between perceived environmental comfort and architectural-functional appropriateness. Such distinction has practical implications for future research and policy-making, as interventions aimed at improving teleworking conditions should address not only environmental comfort parameters but also the physical design and spatial quality of the workspace itself.

In addition, the concept of home-based teleworking was consensually defined, distinguishing it from other forms of remote work and establishing a clear reference framework for its evaluation in future studies. Although the COVID-19 health crisis prompted renewed interest in examining teleworking undertaken in the home—owing to its widespread adoption and its direct link with housing and environmental conditions—there is still no consensus definition that strictly differentiates residential teleworking from other remote working modalities.

Studies such as those by Bailey and Kurland (2002) had already highlighted definitional issues surrounding teleworking, emphasizing the lack of clarity regarding who teleworks, under what conditions, and what the effects are. These authors advocated for a broad view of the phenomenon, recognizing its diversity in terms of frequency, modalities, and locations, rather than categorizing it rigidly. Meanwhile, Messenger and Gschwind (2016) proposed an evolutionary classification of teleworking into three generations—Home Office, Mobile Office, and Virtual Office—reflecting how remote work has diversified thanks to advances in information and communication technologies. Although the Home Office represents one of these forms, their approach does not limit itself to a strict differentiation between domestic spaces and other environments but rather seeks to understand the phenomenon as a whole. Both studies underline the need for greater conceptual clarity in telework research but do not establish a categorical distinction between "working from home" and other forms of remote work. In contrast, the COVID-19 crisis, as noted by the International Labour Organization (ILO 2020), prompted a more specific focus on residential teleworking due to the urgent need to ensure workers' health and safety during periods of lockdown. This new context has provided an opportunity to more clearly delineate the analysis of the environmental and organizational conditions of teleworking conducted exclusively from home.

Consequently, this study adopts and proposes a precise definition of working from home, distinguishing it from other forms of remote work, with the aim of providing a robust framework to specifically assess the indoor environmental conditions of the domestic space intended for teleworking. Unlike traditional workspaces, such as offices or corporate centres, which are subject to specific health and safety regulations, private homes constitute personal spaces where there is no strict regulation regarding environmental conditions for work. This lack of formal regulation makes it even more necessary to clearly delineate the concept of working from home, in order to adequately analyze the factors of comfort, wellbeing, and health affecting teleworkers in their own residences.

To summarize, these results underscore the need to address the physical and environmental conditions of the built environment for working-from-home in an integrated manner, in order to promote home-based teleworking spaces as healthy, efficient, and sustainable settings.

Although the questionnaire has demonstrated strong conceptual coherence and high internal consistency—particularly for the Physical Adequacy construct—its empirical validation is currently limited to the Spanish context. This may constrain the immediate transferability of the results to other national settings without prior contextual adaptation. In addition, the length of the questionnaire, designed to ensure a comprehensive assessment of social, spatial, and environmental dimensions, may pose challenges for its application in large-scale surveys or time-constrained contexts. Future research could therefore explore the development and validation of a short-form version aimed at facilitating its use in applied, comparative, or policy-oriented studies, while preserving the core conceptual structure of the instrument.

With regard to the analytical structure of the questionnaire, adaptive environmental control behaviors—such as the use of heating, cooling, or artificial lighting—were included within the Indoor Environmental Quality (IEQ) construct, as they mediate the relationship between objective environmental conditions (provided by housing design and constructive featuring) and subjective experience (in which other factors, as reactive behavior, seeking comfort, could be addressed, as coping actions). These behaviors reflect occupants' capacity to respond to environmental stressors and therefore form part of the lived environmental quality of the teleworking space. However, under the premises of this questionnaire, both perspectives might be asked through differentiated questions, in order to better understand which is the cause of the whether it of the environmental discomfort, if any, and if this is alleviated by alternative (active) means - as artificial lighting or heating/cooling devices, or not. Nevertheless, future research could also examine these behaviors as a distinct analytical dimension, particularly in studies focusing on energy use, adaptive capacity, or environmental equity.

Given that private dwellings are not subject to occupational environmental regulations, instruments such as the CHAMBER questionnaire may provide an evidence-based framework to inform future housing and labor policies. By identifying minimum environmental and spatial conditions associated with adequate home-based teleworking, such tools could support the development of guidelines, recommendations, or incentive schemes aimed at improving habitability and protecting workers' health in residential settings, whilst privacy and other sensitive aspects of their private life remain protected.

Finally, the application of the questionnaire in international contexts may present challenges related to differences in housing typologies, cultural practices, and climatic conditions. These factors may influence both environmental perception and adaptive behaviors, making contextual adaptation necessary. Consequently, cross-national applications of the CHAMBER questionnaire should consider cultural and climatic calibration of specific items, while preserving the core conceptual structure to ensure comparability. Moreover, according to future analysis of the replies depending on each region, it is also possible to obtain relevant information on which factors are more valuable for teleworkers according not only to their individual needs, but also to social, economic and cultural conditions surrounding their ways of living and working. This info is key to further implementation of labor and social policies regarding telework, as well as actionable measures to incentive suitable, safe and engaging home-based work environments from companies and/or third parties.

5 Conclusion

This study, conducted within the framework of the CHAmbER research project, has enabled the development of a consensus evaluation tool to analyse the priority environmental conditions for working from home, distinguishing them from other forms of remote work. The results highlighted the importance of both sociodemographic and technological characteristics, as well as environmental factors of the domestic space, such as daylighting, hygrothermal and acoustic comfort, air quality, and ergonomics. It is worth noting that studies on indoor environmental quality in the home workspace for teleworking have traditionally focused on productivity or the experience of discomfort and other health issues, rather than aiming primarily to evaluate the quality of such spaces from a comprehensively environmental perspective.

This contribution not only provides value to the assessment of those environmental conditions of the domestic workspace, but also validates the tool generated to make possible this evaluation worldwide. This relevant step forward will allow to diagnose the existing housing stock wherever needed, what could be helpful to retake the debate on the adequacy of home for this recently-massive home activity and, when relevant, reconsider and balance work and housing design-related regulations, policies and implementation strategies, implied in indoor environmental conditions, and the role of any stakeholder involved, to improve those IEQ conditions for the domestic workspaces.

The agreed definition of working from home also provides a solid conceptual framework for future research and for the design of policies to improve the working environment within the residential context. The developed questionnaire constitutes a robust diagnostic tool that can be applied in future comparative studies and in the formulation of teleworking policies, which is particularly relevant given that homes, as private spaces, lack the specific labour regulations that govern traditional work environments.

Data availability statement

The original contributions presented in the study are included in the article/ Supplementary Material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Spanish National Research Council Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MN-M: Validation, Data curation, Methodology, Conceptualization, Visualization, Writing – review and editing, Writing – original draft, Supervision, Investigation, Funding acquisition, Software, Formal Analysis. PM: Supervision, Investigation, Formal Analysis, Writing – review and editing, Validation, Methodology. TC-V: Data curation, Validation, Supervision, Investigation, Conceptualization, Project administration, Software, Funding acquisition, Resources, Methodology, Writing – review and editing, Visualization.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Abellán García, A., Aceituno Nieto, P., Allende, A., Andrés, A. D., Arenillas, A., Bartomeus, F., et al. (2021). Una visión global de la pandemia COVID-19: qué sabemos y qué estamos investigando desde el CSIC. *Cons. Super. Investig. Científicas (España).* doi:10.20350/DIGITALCSIC/13872

Allen, T. D., Golden, T. D., and Shockley, K. M. (2015). How effective is telecommuting? assessing the status of our scientific findings. *Psychol. Sci. Public Interest* 16 (2), 40–68. doi:10.1177/1529100615593273

Augé, M. (1993). *Los no lugares: espacios del anonimato*. Gedisa Barcelona.

Awada, M., Becerik-Gerber, B., Lucas, G., and Roll, S. C. (2021). Associations among home indoor environmental quality factors and worker health while working from home during COVID-19 pandemic. *J. Eng. Sustain. Build. Cities* 2, 041001. doi:10.1115/1.4052822

Bailey, D. E., and Kurland, N. B. (2002). A review of telework research: findings, new directions, and lessons for the study of modern work. *J. Organ. Behav.* 23 (4), 383–400. doi:10.1002/JOB.144

Basinska, K., Wellens, N. I. H., Simon, M., Zeller, A., Kressig, R. W., and Zúñiga, F. (2021). Registered nurses in expanded roles improve care in nursing homes: swiss perspective based on the modified Delphi method. *J. Adv. Nurs.* 77, 742–754. doi:10.1111/JAN.14644

Brush, B. L., Lee, S. Y. D., Gabrysiak, A., Jensen, M., Wilson-Powers, E., Coombe, C. M., et al. (2024). A CBPR-enhanced Delphi method: the measurement approaches to partnership success case study. *Health Educ. and Behav.* 51, 212–217. doi:10.1177/10901981221076400

Casla-Herguedas, B., Romero-Fernández, A., Carrascal, T., Navas-Martín, M. Á., and Cuerdo-Vilches, T. (2023). Noise perception and health effects on population: a cross-sectional study on COVID-19 lockdown by noise sources for Spanish dwellings. *Buildings* 13, 2224. doi:10.3390/BUILDINGS13092224

Cuerdo-Vilches, T., Oteiza-San José, I., and Navas-Martín, M. Á. (2020). *Proyecto sobre confinamiento social (covid-19), vivienda y habitabilidad [COVID-HAB]*. Paraninfo Digital. e32066o–e32066o.

Cuerdo-Vilches, T., Navas-Martín, M. Á., March, S., and Oteiza, I. (2021a). Adequacy of telework spaces in homes during the lockdown in Madrid, according to socioeconomic factors and home features. *Sustain Cities Soc.* 75, 103262. doi:10.1016/j.scs.2021.103262

Cuerdo-Vilches, T., Navas-Martín, M. Á., and Oteiza, I. (2021b). Working from home: is our housing ready? *Int. J. Environ. Res. Public Health* 18, 7329. doi:10.3390/IJERPH18147329

de Klerk, J. J., Joubert, M., and Mosca, H. F. (2021). Is working from home the new workplace panacea? Lessons from the COVID-19 pandemic for the future world of work. *SA J. Ind. Psychol.* 47, 14. doi:10.4102/SAJIP.V47I0.1883

Egfjord, K. F. H., and Sund, K. J. (2020). A modified Delphi method to elicit and compare perceptions of industry trends. *MethodsX* 7, 101081. doi:10.1016/J.MEX.2020.101081

Eurofound, International Labour Office, Messenger, J., Vargas Llave, O., Gschwind, L., Boehmer, S., et al. (2017). *Working anytime, anywhere: the effects on the world of work*. doi:10.2806/372726

Fathullah, M. A., Subbarao, A., and Muthaiyah, S. (2023). Methodological investigation: traditional and systematic reviews as preliminary findings for Delphi technique. *Int. J. Qual. Methods* 22, 16094069231190747. doi:10.1177/16094069231190747

Felstead, A., and Henseke, G. (2017). Assessing the growth of remote working and its consequences for effort, well-being and work-life balance. *New Technol. Work Employ.* 32 (3), 195–212. doi:10.1111/NTWE.12097

Gobierno, D. E. (2021). *Ley 10/2021, de 9 de julio, de trabajo a distancia*. Available online at: https://www.boe.es/eli/es/l/2021/07/09/10.

Graefe, A., and Armstrong, J. S. (2011). Comparing face-to-face meetings, nominal groups, Delphi and prediction markets on an estimation task. *Int. J. Forecast* 27, 183–195. doi:10.1016/J.IJFORECAST.2010.05.004

Gupta, U. G., and Clarke, R. E. (1996). Theory and applications of the Delphi technique: a bibliography (1975–1994). *Technol. Forecast Soc. Change* 53, 185–211. doi:10.1016/S0040-1625(96)00094-7

Gustafson, D. H., Shukla, R. K., Delbecq, A., and Walster, G. W. (1973). A comparative study of differences in subjective likelihood estimates made by individuals, interacting groups, Delphi groups, and nominal groups. *Organ Behav. Hum. Perform.* 9, 280–291. doi:10.1016/0030-5073(73)90052-4

Information Resources Management Association (2021). Research anthology on business strategies, health factors, and ethical implications in sports and eSports. *IGI Glob.* doi:10.4018/978-1-7998-7707-3

Jaimes Torres, M., Aguilera Portillo, M., Cuerdo-Vilches, T., Oteiza, I., and Navas-Martín, M. Á. (2021). Habitability, resilience, and satisfaction in Mexican homes to COVID-19 pandemic. *Int. J. Environ. Res. Public Health* 18, 6993. doi:10.3390/ijerph18136993

Kamaruzzaman, S. N., Lou, E. C. W., Wong, P. F., Edwards, R., Hamzah, N., and Ghani, M. K. (2019). Development of a non-domestic building refurbishment scheme for Malaysia: a Delphi approach. *Energy* 167, 804–818. doi:10.1016/J.ENERGY.2018.11.020

Keeney, S., Hasson, F., and Mckenna, H. (2010). *The Delphi technique in nursing and health research*. The Delphi Technique in Nursing and Health Research. doi:10.1002/9781444392029

Keyvanfar, A., Shafaghat, A., Abd Majid, M. Z., Bin Lamit, H., Warid Hussin, M., Binti Ali, K. N., et al. (2014). User satisfaction adaptive behaviors for assessing energy efficient building indoor cooling and lighting environment. *Renew. Sustain. Energy Rev.* 39, 277–295. doi:10.1016/J.RSER.2014.07.094

Ko, W. H., and Lu, M. Y. (2020). Evaluation of the professional competence of kitchen staff to avoid food waste using the modified Delphi method. *Sustainability* 12, 8078. doi:10.3390/SU12198078

Krauss, G., and Tremblay, D. G. (2024). Third places, coworking, and coworking spaces as concepts responding to current social and economic trends. *Coworking Revolut. Work. Living New Territ.*, 7–25. doi:10.4337/9781802209181.00010

Lescarret, C., Lemercier, C., and Le Floch, V. (2022). Coworking spaces vs. home: does employees' experience of the negative aspects of working from home predict their intention to telework in a coworking space? *Front. Psychol.* 13, 1079691. doi:10.3389/FPSYG.2022.1079691

Linstone, H. A., and Turoff, M. (1975). *The Delphi method: techniques and applications*. Addison-Wesley Publishing Company, Advanced Book Program.

López-Igual, P., and Rodríguez-Modroño, P. (2020). Who is teleworking and where from? Exploring the main determinants of telework in Europe. *Sustainability* 12, 8797. doi:10.3390/SU12218797

Lozano-Cabedo, C., Moreno, M., Díaz-Méndez, C., Ajates, R., and Navas-Martín, M. A. (2025). Scientists' views on sustainable healthy diets: a reflection process towards a multi-disciplinary consensus. *Sustainability* 17 (10), 4542. doi:10.3390/su17104542

Mahajan, V., Linstone, H. A., and Turoff, M. (1976). The Delphi method: techniques and applications. *J. Mark. Res.* 13, 317. doi:10.2307/3150755

Meijering, J. V., Tobi, H., van den Brink, A., Morris, F., and Bruns, D. (2015). Exploring research priorities in landscape architecture: an international Delphi study. *Landsc. Urban Plan.* 137, 85–94. doi:10.1016/J.LANDURBPLAN.2015.01.002

Messenger, J. C., and Gschwind, L. (2016). Three generations of telework: new ICTs and the (R)evolution from Home Office to Virtual Office. *New Technol. Work Employ.* 31 (3), 195–208. doi:10.1111/NTWE.12073

Moretti, A., Menna, F., Aulicino, M., Paoletta, M., Liguori, S., and Iolascon, G. (2020). Characterization of home working population during COVID-19 emergency: a cross-sectional analysis. *Int. J. Environ. Res. Public Health* 17 (17), 6284. doi:10.3390/IJERPH17176284

Morisson, A. (2017). A typology of places in the knowledge economy: towards the fourth place. *SSRN Electron. J.* doi:10.2139/SSRN.3056754

Navas-Martín, M. Á., and Cuerdo-Vilches, T. (2023). Natural ventilation as a healthy habit during the first wave of the COVID-19 pandemic: an analysis of the frequency of window opening in Spanish homes. *J. Build. Eng.* 65, 105649. doi:10.1016/J.JOBE.2022.105649

Navas-Martín, M. Á., Oteiza, I., and Cuerdo-Vilches, T. (2022). Dwelling in times of COVID-19: an analysis on habitability and environmental factors of Spanish housing. *J. Build. Eng.* 60, 105012. doi:10.1016/j.jobe.2022.105012

Navas-Martín, M. Á., Jiménez-Planet, V., and Cuerdo-Vilches, T. (2025). Working from home and indoor environmental quality: a scoping review. *Appl. Sci.* 16 (1), 250. doi:10.3390/app16010250

Nguyen, H. Q., Serret, H., Bae, Y., Ji, S., Chae, S., Kim, Y. I., et al. (2020). Not all cicadas increase thermal tolerance in response to a temperature gradient in metropolitan Seoul. *Sci. Rep.* 10 (1). doi:10.1038/s41598-020-58276-0

Oldenburg, R. (1989). The great good place: Cafés, coffee shops, community centers, beauty parlors, general stores, bars, hangouts, and how they get you through the day.

Park, S. Y., Newton, C., and Lee, R. (2023). How to alleviate feelings of crowding in a working from home environment: lessons learned from the COVID-19 pandemic. *Int. J. Environ. Res. Public Health* 20, 1025. doi:10.3390/IJERPH20021025

Qi, Z., Lee, D., Lee, S., Jeong, T. K., and Kim, S. (2011). A health performance evaluation model of apartment building indoor air quality. *Indoor Built Environ.* 20, 26–35. doi:10.1177/1420326X10393719

Rotimi, J. O. B., Moshood, T. D., and Rotimi, F. E. (2024). The potential challenges and limitations of implementing modern office design features in residential spaces: a SPAR-4-SLR approach. *Buildings* 14, 3037. doi:10.3390/BUILDINGS14103037

Shockley, K. M., and Allen, T. D. (2024). Remote work: post-COVID-19 state of knowlegde and best practice recommendations. Available online at: https://www.infocop.es/wp-content/uploads/2024/10/Remote-Work-Post-COVID-19-State-of-the-Knowledge-and-Best-Practice-Recommendations.pdf (Accessed March 30, 2025).

Skulmoski, G. J., Hartman, F. T., and Krahn, J. (2007). The Delphi method for graduate research. *J. Educ. Technol.* 6, 1–21.

Sobaih, A. E. E., Ritchie, C., and Jones, E. (2012). Consulting the oracle? applications of modified Delphi technique to qualitative research in the hospitality industry. *Int. J. Contemp. Hosp. Manag.* 24, 886–906. doi:10.1108/09596111211247227

Thangaratinam, S., and Redman, C. W. (2005). The Delphi technique. *Obstetrician and Gynaecol.* 7, 120–125. doi:10.1576/TOAG.7.2.120.27071

Valerino-Perea, S., Armstrong, M. E. G., and Papadaki, A. (2021). Development of an index to assess adherence to the traditional Mexican diet using a modified Delphi method. *Public Health Nutr.* 24, 4387–4396. doi:10.1017/S1368980020004565

Vio, F., Olaya, M., Fuentes-Garcí, A., and Lera, L. (2020). Delphi method to reach consensus on education methods to promote healthy eating behaviors in adolescents. *Nutr. Hosp.* 37 (4), 838–849. doi:10.20960/NH.02922

von der Gracht, H. A. (2012). Consensus measurement in Delphi studies: review and implications for future quality assurance. *Technol. Forecast Soc. Change* 79, 1525–1536. doi:10.1016/J.TECHFORE.2012.04.013

Yuan, J., Zhao, X., Segun, G. A., Vakili, M., and Zhong, L. (2021). Indoor environmental health assessment in eco-building and its case study. *Atmosphere* 12, 794. doi:10.3390/ATMOS12060794