

# Adequacy of telework spaces in homes during the lockdown in Madrid, according to socioeconomic factors and home features

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## ABSTRACT

In Spain, the COVID-19 confinement was carried out in the spring of 2020. All non-essential activities were temporarily suspended. This brought with it the adaptation to home office (telework), still emerging in Europe, and more in Spain. Although the response in general has been positive, the conditions to which families have been subjected to telework cannot be considered normal. In this context, an online survey was requested to find out the experience of confined households in relation to the dwelling adaptation and satisfaction following the new needs in lockdown. The data obtained on workspace perception and its adequacy were studied in Madrid, stratified by gender and average income, for a sample of 256 households with people teleworking or studying. The results showed that the adequacy of telework spaces were insufficient for a third of the households, with no significant relationship with most of socioeconomic variables, nor with home characteristics. The variables related to this inadequacy of the spaces were: the number of people who work or study at home; the lack of exclusive spaces for teleworking; and the availability of digital resources. This perception also depended on the qualities of the teleworking space, as size, furniture and lighting, among others.

## 1. Introduction

Working from home has undoubtedly been an option for most workers as a result of the lockdown due to COVID-19. In Spain, in 2019 only 8% of workers practiced teleworking, while the European average was a 15% for this period (Joint Research Centre 2020).

This development has posed a challenge for all these households when it comes to including teleworking as another home activity. The need to dedicate specific spaces and resources has led to unprecedented adaptations in many of them.

Following the declaration of the SARS-CoV-2 pandemic by the World Health Organization (WHO) (World Health Organization 2020), the Spanish government established social confinement as a public health measure (Gobierno de España, 2020). This preventive and containment measure was then adopted by many other countries, given the rapid spread of the virus throughout the world (Chakraborty and Maity, Aug. 2020).

The reality lived during the spring of 2020 implied an unprecedented experience for the population. In the period between March 14 and June

21, 2020 (Gobierno de España, 2020; Gobierno de España, 2020), the Spanish Government decreed a State of Alarm, which entailed, among other measures, staying inside the home, as well as the restriction of non-essential activities and the closure of schools at all levels. This set off a new way of experiencing housing. All activities, both usual and those that traditionally took place outside the home, now had to be carried out indoors (Santiago et al., Jan. 2021).

Depending on the experiences of the households, the perception of satisfaction and adaptive capacity to the new needs were very different. Families and dwellings responded resiliently to the extent that they met the requirements of spatial adaptation, redistribution of tasks and organization (Balanzá-Martínez et al., May 2020), habitability, indoor environmental quality, comfort, and in general, responding to the daily challenges that the household demanded (Cuervo-Vilches et al., Dec. 2020).

Among all these activities centralised in the house, working from home was an option for many households, whose work activity allowed them to relocate (Ruiz-Frutos et al., Jan. 2021). This facilitated the protection of workers (Belzunegui-Eraso and Erro-Garcés, May 2020), as

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well as compliance with social isolation, initially helping families to remain at home with their children and dependents (Aguilera, Lethiais, Rallet, & Proulhac; Viglione), although the experience was unevenly perceived in terms of family and work reconciliation (Lim et al.; Sullivan & Lewis, 2001).

The pandemic and teleworking have highlighted the existing imbalance between men and women regarding work and personal life (Ahrendt et al., 2020), as women have not been able to devote comparatively much time to their work (Bisello et al., 2020). During this period, more than twice as many women decided to stay at home, while men went more out to work (Oliver et al., Sep. 2020). The care of children, the elderly and other dependents has fallen mainly on women, both because of increased work pressure and social conventions (United Nations, 2020).

On the other hand, not all households have enjoyed ideal conditions for teleworking. Access to the necessary energy (Hesselman et al., 2019), the availability of internet connection or digital resources to study or work remotely, as well as the reduction in income of many households due to the decrease in employment in this period, show the countless gaps that have been accentuated among the most vulnerable (Mikolaj et al., Jul. 2020).

The functionality of the dwelling has undergone a major conceptual shift in the wake of total lockdown due to the pandemic. If previously it was considered a place to carry out basic life activities mainly, now it has likewise occupied working hours, since they also had to be done from the home. Therefore, the determination of the quality of spaces and environmental conditions, in terms of habitability, healthiness, comfort and satisfaction with them, must be assessed taking into account the possibility of overexposure to these factors (Tleuken et al., 2021), by a part of the population that may be important in contexts such as a health emergency, and that, in any case, could be increasingly growing in proportion if this work modality is accepted at a general level.

In Spain, more than half of the dwellings of first occupation (regular dwellings) were built prior to regulations on thermal and acoustic insulation (Gobierno de España, 2020), (Cuervo-Vilches & Navas-Martín, 2021). Almost all of these dwellings were developed before the current regulations, in force since 2007, which establish specific requirements on indoor comfort and environmental quality (Gobierno de España, 2006).

Since 2017, there has been a notable growth in terms of rehabilitation activity in the residential sector at national level, with an estimated increase of almost 20 % in the number of renovation, refurbishment and restoration works on dwellings. In general, rehabilitation activity has exceeded new construction in Spain in terms of turnover since 2012. In 2018, renovations occupied 54.3% of the sector's activity (Gobierno de España, 2020). However, during lockdown, defects were still observed in the houses, such as poor or insufficient insulation in 40% of them (Cuervo-Vilches et al., Dec. 2020).

The interest of this study is to highlight the importance of teleworking in these households, and the environmental conditions and resources to develop it at home during lockdown. This may have an impact on the teleworker's overall sense of satisfaction and well-being, both physically and emotionally (Azizi et al., Oct. 2020).

## 2. Literature analysis

### 2.1. Telework before the COVID-19 crisis. A question of Sustainability

Although teleworking in the COVID-19 context is a novel topic, its implementation as a work modality, and all that it entails, has been the subject of study for decades.

Among the most recurrent aspects to be analyzed, the reasons for its reluctance in companies and even for the employees themselves to adopt it, have been the real benefits that it can imply at different scales, as well as the uncertainties or other concerns that may arise from its application. Different approaches have emerged from the analysis of real versus

theoric experiences.

Indeed, the relationship of teleworking with the three main aspects of Sustainability has always been subject of debate. Environmentally, since the mobility of the teleworker reduces fossil energy consumption, as well as air pollution and other associated emissions (de Abreu e Silva & Melo; Giovanis; Guerin; Zhang, Moeckel, Moreno, Shuai, & Gao).

However, it does not seem to be too clear. In the first place, because the benefits do not seem to be so many when all forms of worker mobility are evaluated (Aguilera et al., Oct. 2016), and secondly, if teleworkers save in the number of trips in total, since they reduce the number of work trips, but they are longer. Other authors even suggest the origin of greater mobility for non-work reasons, although the real causality in choosing the home location and teleworking cannot be attributed in a finalist way. What does seem to be a trend is that those who opt for more remote places try to telework (de Abreu e Silva & Melo; Moeckel, Heilig, Hilgert, & Kagerbauer, 2020).

Regarding the economic aspect, linked to the productivity and benefits associated with the production of the companies and the performance of the employees, there are also many issues faced. On the one hand, there is the vision of the company or the employer, and their reluctance, once again. These are derived from the necessary internal organizational changes in companies (Rietveld, Jun. 2011), as well as from the information security tools to be applied in teleworking (Silva-C et al., Nov. 2019), and technological investments (Aguilera et al., Oct. 2016). Added to these reluctance is the uncertainty due to the way of controlling the work carried out by employees, which would become based on objectives or results (Groen et al., Dec. 2018).

There are also doubts in relation to a greater effective productivity of the teleworker. Some studies suggest that this depends, in part, on the hours dedicated to this activity, and is also related to the efficiency derived from avoiding travels, the greater the longer these are (Kazekami, Mar. 2020). Although in creative processes, this productivity does not seem to diminish in teamwork when a minimum of face-to-face contact is maintained with the team, to allow the exchange of knowledge (Coenen and Kok, Aug. 2014).

As for the social aspect, this is not without debate. In the first place, neither in the literature there is unanimity on the benefits reported or expected from the conciliation of working and living. Some authors point out nuances that have to do with the composition of the home, and with the vital stage of the people, since it not only implies reconciling with care, but also with the necessary redistribution of domestic tasks within the household (Zhang et al., Nov. 2020, Silva-C et al., Nov. 2019). In addition to this, teleworking is linked to certain employee profiles (Aguilera et al., Oct. 2016), which tend to be people with a higher income, being self-employed, having university studies, and being a man, most prone to teleworking (de Abreu e Silva and Melo, Dec. 2018). Finally, other reluctances come from the hand of behavioral, cultural and even political aspects, both for employers and employees, as well as the need for actors to facilitate the transition to the new working model, in the face of the entrenched traditional way, and even mobility, lack of policies and legitimacy (Hynes, Sep. 2016). This in definitive, would entail changes in lifestyles and activity patterns of the workers (Rietveld, Jun. 2011).

For all these reasons, for Stiles, what could be an option to be taken as a social imperative, seems to be shifting towards strategic niches more related to the human resources area (Stiles, Mar. 2020).

The greatest transversal limitation to all these debates is precisely the theoretical nature of many of these studies, where various methods, highlighting models, are applied to be able to foresee possible scenarios and their consequences or implications, although primary data and surveys have also been studied.

### 2.2. The workspace. Implications for well-being and health

As for the quality of the workspace, it has evolved a lot in recent years. Not only in terms of the health and safety of the worker, but also

in their well-being, which results in their motivation and productivity (Andargie and Azar, Apr. 2019), giving rise to innovative, more flexible configurations to achieve their satisfaction and increase their creativity (Babapour Chafi et al., Feb. 2020). There are studies that have delved into these characteristics and how certain spatial and location aspects of jobs affect the subjective appreciation of it by their occupants, on a day-to-day basis (Tan et al., Jul. 2020), even depending on the type of work they do (Su et al., Nov. 2020). Some authors suggest working on the designs, including aspects such as privacy or personalization of these work environments (Haapakangas et al., Nov. 2018). Others, however, are focused on more objective qualities related to indoor environmental quality and its effect on people's health (Martins and Carrilho da Graça, Jul. 2020).

There has been normative in this regard for decades, which controls the related features in the offices and places intended in a stable way for this purpose through fields of knowledge such as Hygiene, Health and Safety in the workplace, (Gobierno de España, 2021) or the prevention of occupational risks (Gobierno de España 1995). However, the lack of stable and recurrent remote work practice by a large proportion of workers has not led to the widespread formalization of measures in non-working areas such as housing. Relevant characteristics of these environments are adequate lighting, indoor air quality, thermal and acoustic comfort, and user comfort with respect to the furniture and digital resources that they need to use (Government of the United Kingdom Mar, 2013).

However, there are studies that have addressed some of these facets from ergonomics and their effect on people's health, and potential areas for improvement, among others, in the design of the remote workstation (Montreuil and Lippel, Jun. 2003). Most of these studies focus on control over injuries, symptoms or pain, and how to tackle them, as well as the costs they entail for health systems (Kalkis, Jan. 2015). Ergonomics, safety and health of workers are often encompassed within the socio-technical approach or theory, which groups both the needs of the person as an individual, and as a body of the organization, therefore valuing their role in the company and its performance (Bentley et al., Jan. 2016). The search for improvement in the health of the teleworker population has led to the creation of new tools and technologies that enhance this work modality (Gopinathan and Raman, Nov. 2015), such as Healthcare Information Technology (HIT) (Hedge et al., Jul. 2011). More recently, it has been addressed how Industry 4.0 can favor these human and ergonomic aspects in the field of teleworking (Kadir et al., Nov. 2019).

Many of these studies finally coincide in the necessary training in ergonomics and safety issues as a necessary factor to guarantee the application of measures such that the teleworker is satisfied with this type of work, as well as to avoid potential health problems (Harrington & Walkers; Hedge, James, & Pavlovic-Veselinovic).

However, from the spatial and functional point of view of the working area of the housing intended for teleworking, the telework space has never been studied, as far as our knowledge reaches, bringing together simultaneously the following characteristics: 1) assessing in detail the different characteristics of the telework space, 2) from a user-centered point of view, in their subjective perception and their level of satisfaction, 3) belonging to different organizations, or being self-employed, and 4) with a considerable sample for the same urban environment.

### 2.3. Teleworking in the context of the COVID-19 pandemic

The COVID-19 pandemic has caused numerous impacts, with effects expected in the medium-long term. In the socioeconomic aspect it has not been less, so the United Nations has assessed the effect of the pandemic within the targets of the Sustainable Development Goal (SDG) 8, on decent work and economic growth. In this sense, the integrated package of actions to provide socio-economic responses, the United Nations Development System (UNDS), established a series of concrete

measures to alleviate the high socioeconomic impact of the pandemic, one of which clearly establishes specific and integrated policy advice for each country, and program support. In this concept, it encompasses protecting workers and those sectors on which the crisis has most impacted, and how to prevent the collapse of economic activity and jobs. One of the ways is to protect households and individuals by expanding social protection, as well as promoting teleworking and job-sharing policies. This technical report issued by the UN on updating measures as a result of the COVID-19 pandemic, emphasizes the need to undertake them under the imperative of environmental sustainability, and the commitment of a more resilient world economy to future shocks (United Nations, 2020).

There are many studies on COVID-19 that have taken into account the influence of confinement as a protection measure for citizens. More specifically, there is literature that delves into their sustainability and how this has been affected by the application of the measures against COVID-19 adopted by the different countries.

Among some of the aspects addressed, technology stood out as a key factor, since the so-called smart cities, contributed to preventing and controlling the spread of the disease in countries like China. Electronic services allowed the reduction of physical contact and expendable mobility (Yang and Chong, Jul. 2021).

Other aspects that have determined the adaptive or resilient capacity of cities in the face of such an emergency have mainly been economic activity, linked to population density and mobility, and the health resources available. In this sense, if the city is more dependent on the labor mobility of its citizens, the risks of contagion increase, and the demand for such resources does too (Chen et al., Jul. 2021). In this equation of factors that influence the transmission of contagion, the level of education and income also intervenes, where the most disadvantaged are not only less aware of the risks of transmission, but are also less susceptible to applying prevention measures, and less likely to telecommute (Khavarian-Garmsir et al., Jul. 2021).

On the other hand, the confinement has had a positive impact on the reduction of energy consumption in the tertiary sector. In a way, this consumption was transferred to the home (Cuervo-Vilches et al., May 2021), where it is estimated that one day of teleworking represented an increase of between 7 and 23% of consumption (Saif-Alyousfi and Saha, Jul. 2021). This general decrease in energy consumption also occurred as a consequence of reduced mobility due to road traffic. This in turn led to a reduction in pollution, and associated emissions, with better outdoor air quality (Han, Zhao, & Gu; Polednik; Sathe et al.; Xin, Shao, Wang, Xu, & Li), and a decrease in noise pollution (Basu et al., Feb. 2021).

Building density is another factor that influences the number of COVID-19 infections. On the one hand, a higher density concentrates a greater number of households, at the same time that it leads to smaller houses, making it more difficult to maintain an effective distance (Lak et al., Sep. 2021).

Other characteristics of the house also affect the advance of the pandemic, given the uncertainty derived from the prolongation of periods of confinement in it. For this reason, new designs will be necessary to improve spatial organization, where the space intended for work in the home is also considered (Megahed and Ghoneim, Oct. 2020).

Regarding the indoor environment in the home, the air quality stands out for its impact on the health of the residents. Greater exposure can increase the origin or worsening of respiratory problems, drowsiness, or irritations in the mucous membranes, such as the throat (Agarwal et al., Jul. 2021).

Therefore, it can be seen that there are many studies that analyze the incidence of the COVID-19 pandemic, and more specifically confinement, in the operation of cities and their sustainability. However, as far as our knowledge reaches, there are no analyzes in detail on the adequacy of workspaces of homes that have had to telework. Faced with the research question of: how teleworker households have adapted to this new task, at a spatial, functional and resource-availability level? this

study arises. Its main objective is to find out to what extent households in the city of Madrid have had adequate teleworking spaces, in relation to certain sociodemographic variables and the composition of such households.

With this study, it is expected to contribute to the taxonomization of the telework space, its characteristics and the subjective adaptation to the teleworker's needs, associating it with certain patterns of household composition, and sociodemographic variables. These results can help decision-making in the face of possible similar situations, in contingency plans, as well as influence the design of better cities and houses, which allow a sustainable and resilient development of activities, both traditional and new (among which telework would be found in such a high proportion), even in the face of such extreme emergencies as the one experienced as a result of COVID-19. On the other hand, this study aims to contribute to the debates on the effective application of telework, its real application capacities, the subjective perception and the level of satisfaction of these workspaces according to its practitioners, and how they affect their socioeconomic qualities in real practice. Finally, knowing the impacts of such an unusual situation at a global level can help to define in greater detail these and other possible scenarios in the face of new paradigms of design, rehabilitation and intervention both in the residential sector and at the urban level, which affect the three major aspects of sustainability: social, economic, and environmental.

### 3. Study area: general information, work culture and working habits

#### 3.1. Study area: general data

The study area is focused on the municipality of Madrid. It is the municipality with the largest population, with a total of 3,334,730 inhabitants (Ayuntamiento de Madrid 2020). In turn, there are 1,307,682 dwellings of primary use, giving an average household size of 2.55 persons (Ayuntamiento de Madrid 2020).

The majority group of people is between 16 and 64 years old (66.21%), compared to 27.11% over 65. On the other hand, the smallest group is those under 15 years, with 13.76%. The average age of Madrid citizens is 44.18 years (Ayuntamiento de Madrid 2021). The average income per person compared to 2018 in Madrid was € 15,203 above the national value, which corresponds to € 11,680. At the household level, the average income was € 35,544, being above the Spanish value of € 29,131.

The surface area of Madrid is 60,445.52 Ha, so the population density is 55 p/Ha. The municipality is administratively organised into 21 districts, subdivided into neighbourhoods. Although data were obtained from more Spanish municipalities, only Madrid was used for this work because it provided good information on average household income by district, which could be easily added the study data, thus allowing to add more socioeconomic variables to the analysis. According to cadastral data, the mean value of built surface for dwellings is 115.42 m<sup>2</sup>, and with an average age of 38 years (Ayuntamiento de Madrid 2020). The average price per m<sup>2</sup> of new homes in Madrid is 2,914 (€ / m<sup>2</sup>) and 3,473 (€ / m<sup>2</sup>) of used homes. At the level of equipment in homes, 87.8% have some type of computer and 94.5% have Internet access (Ayuntamiento de Madrid 2019).

With regard to occupational level, the activity rate of the population over sixteen years of age stood at 61.7%, being above the national rate (57.7%). In contrast, the unemployment rate was 12.2%, below the national rate (16%) (Ayuntamiento de Madrid 2021).

#### 3.2. Work culture and working habits

Despite Madrid enjoys international projection as the capital of Spain, this city shares much of the idiosyncrasy and the way of conceiving work with the rest of the nation. In Spain, there is a fairly general informal culture based on labor presenteeism. This consists of

unnecessarily lengthening the working day, or going even being ill, for fear of reprisals in the presence of higher-level managers in the workplace, for instance. Presenteeism generates a false sense of work efficiency, relating salary to hours spent at the office, and not to performance or productivity. Above all, this model stands out in companies that establish rigid working hours (Arredondo, 2010; Leivar Santiago, 2017; Rodríguez Canfranc, Villar García, Tarín Quirós, & Blázquez Soria, 2021; Gobierno de España 2021). Another reason for extending the working day is the traditional split-shift schedule, common in this country (Gracia and Kalmijn, Apr. 2016) This, together with long journeys back home, and a time zone not in accordance with the actual hours of sunlight, reduces the time spent with the family, altering in many cases the rest.

The Spanish working week, stipulated at 40 hours, is one of the highest in Europe, after the Netherlands (30 hours), Denmark (32 hours), Norway and Germany (34 hours), although other non-European countries exceed 60 hours. A study carried out by the International Labor Organization (ILO) in 2019 shows that the best place to reconcile work and family life is precisely in the Netherlands (Eurofound and International Labour Organization 2019).

According to the Adecco report made to workers from different countries during the COVID-19 pandemic, including Spain, 72% of those surveyed in this country recognized that a review was necessary in the working day. In turn, three out of four respondents would like to have flexible hours, or maintain the flexibility obtained after the pandemic.

In the aforementioned report, confinement at the most critical time of the pandemic has shown that remote work is effective, productive and flexible. For this reason, the employees surveyed at the time, requested greater flexibility in returning to the "new normal". 77% of those surveyed considered that the ideal work model in the post-covid era was one that combines face-to-face work with remote work. In addition, 80% of the participants demanded greater flexibility, both in the way of performing their functions and in the place where they should be performed (Adecco Group Institute, 2020).

Another report from the same entity, on teleworking and occupational health in Spain, states that the expectations of companies about maintaining or implementing remote work after the end of the pandemic have improved: they have risen almost 4 percentage points (to 23%), while those that would not opt for this flexibility model fell 9 points, to 21%. 63% of the participating organizations have a positive or very positive perception of productivity in teleworking, and only 9% have seen it negative. 44% of these companies state that two days of teleworking would be the ideal in a post-covid scenario. As a negative point, 55% of those surveyed perceive cognitive and mental problems, as risk factors and disability after the pandemic, due to problems posture, musculoskeletal disorders, or anxiety and stress, respectively (63%). Another delicate point has been the increase in the COVID-19 period of presenteeism, of up to 3.4 percentage points, and also the increase in absenteeism (Adecco Group Institute, 2021).

One aspect to consider is the scarcity of scientific and empirical studies dealing with telework as a subject, and more specifically the suitability of spaces in dwellings for this task, especially in situations of confinement, the main singularity of which has been that the family nucleus has been kept locked up in the house all the time.

This may be related to the lack of widespread practice, at least in much of Europe, of this mode of work prior to the COVID-19 pandemic. In Europe, the average proportion of teleworkers in 2019 was almost 15%, while in Spain this average value was barely 8%, with countries such as Sweden and the Netherlands standing out at around 35%. However, in all countries, including those with the highest percentages of experience in this type of work, a majority proportion of these teleworkers practiced it on an occasional basis (Joint Research Centre 2020).

Therefore, this mode of work is considered to be recent, and the definitive trigger has been the lockdown. So much so, that countries all over the world have decided to include conditions for teleworkers at a

regulatory level, such as Spain (Gobierno de España, 2020) or Mexico (Gobierno de México, 2021).

For all these reasons, at the beginning of 2021 a petition arose to the national government where it was suggested to pilot incentivize a reduction of the working day of 4 days and 32 hours per week in certain sectors without a reduction in salary (Kassam, 2021). Apparently this suggestion could take effect in the autumn of this year 2021. This reduction would be supported by an idea of greater efficiency and productivity, better work-life and family balance, and more time of rest and dedication to other activities, for the worker's well-being. Meanwhile, even in mid-2021 there are many companies in Spain, and more specifically in Madrid, that are in transition from teleworking due to COVID-19 to face-to-face mode, in which they decide how to formalize, in each case, the form of adapting this modality more permanently, once the COVID-19 pandemic ceases. Undoubtedly, the emergence of telework in a massive way contrasts greatly with the presentist tradition characteristic of the Spanish work culture, so the opportunity to undertake a study of these characteristics seemed urgent and opportune, unprecedented to date, up to our knowledge.

#### 4. Methods

This contribution is based on an analysis framed within the project on COVID-19 confinement, housing and habitability (Cuervo Vilches, Oteiza San José, & Á. Navas Martín, 2020). This project consisted of an exploratory mixed-method study, at the national level, where the participants, representatives of Spanish households in confinement due to COVID-19, were able to answer anonymously two online forms about the housing experience during the confinement, in relation to their daily activity, adaptation of habits, detection of needs and preferences, and level of satisfaction with the home and its different living spaces. For this study, the aspects of the questionnaire related to telework, the socio-demographic factors of households, and the characteristics of dwellings, and in particular, those of the spaces occupied to work at home, were taken into account for the city of Madrid. This project was approved by the Ethics Committee from the Spanish National Research Council (CSIC), with report number 057/2020.

##### 4.1. Data collection and recruitment

The results obtained for the municipality of Madrid, were used to find out users' perceptions of their housing and teleworking conditions during lockdown.

A dissemination strategy for the study was defined for the recruitment of participants, through different online channels: institutional websites, social networks, and email. In particular, the *web scraping* technique was used to obtain the contacts of neighbourhood associations and their federations, cultural associations, and city councils throughout the country. In the case of Madrid, more than 200 entities were contacted and acted as loudspeakers for the study and facilitators.

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

The quantitative online questionnaire consisted of a survey, with 58 questions, including numerical, categorical, and Likert-type responses with 5- or 7- category scales. From among the themes of confinement and household and dwelling characteristics, those questions related to socio-demographic data and the five questions on teleworking were chosen for this analysis.

##### 4.2. Used variables

The variables chosen for the analysis were grouped into seven categories (Table 1). Of these variables, six were obtained from the questionnaire, and the last one, corresponding to income level adapted by postcode, was extracted from data available from the National Institute

**Table 1**

Relationship of variables by categories and origin of the study data.

Category	Variables
<b>Socioeconomic factors</b>	Age, gender, job occupation, educational level, country of birth, average income quartile of the area of residence
<b>Household composition</b>	Cohabitants, age of the same, minors or seniors in charge.
<b>Housing conditions</b>	Occupancy regime of the home, useful area, useful area per person.
<b>Dwelling quality</b>	General lighting, air quality, noise insulation.
<b>Digital resources</b>	Perception of the adequacy of digital media for teleworking.
<b>Material conditions for teleworking</b>	People who work/study at home, type of telework space, perception of the global adequacy of this space, adequacy of the characteristics of the telework space
<b>Income level</b>	Quartiles of the average income level by district

of Statistics (Instituto Nacional de Estadística 2021).

Housing quality conditions are mainly related to environmental quality. For this purpose, general lighting, air quality and noise insulation were assessed using Likert-type scales with values from 1 to 5, with 1 being the most unfavourable and 5 the most favourable. Similarly, digital resources were assessed on a Likert scale from 1 to 5, with 1 being poor and 5 very good.

As for the variables related to the material conditions for teleworking, the respondents were asked who teleworked or studied from home, distinguishing whether there were one or more people in the household in this situation, and whether or not the respondent was one of them. Regarding the type of telework space, a distinction was made between: exclusive telework space (office), regular shared space (e.g. multi-purpose room or bedrooms with work/study areas), occasional shared space (temporarily prepared dining room or living room), and no fixed location (roaming occupation). The suitability of the telework space was also valued with a Likert-type variable from 1 to 5. Subsequently, the suitability of eleven aspects related to this space were assessed: size, temperature, daylighting, artificial lighting, general noise insulation, windows (joinery and glazing), solar control devices (blinds, awnings, others), surface finishings, furniture, views from windows to the outside, space for vegetation, and others (to be specified).

Regarding the economic variable considered, the average income, this had to be adapted in two ways. On the one hand, quartiles were established for its management. On the other, since the original variable was obtained by district, the administrative division of the municipality, it had to be adapted to the only geolocation data of the participating households as it was an anonymous study, the postcode. The free software QGIS (Freeman et al., 2021) in its version 3.16 was used for the delimitation of the districts and their subsequent correspondence with the postcodes. The available maps of territorial delimitations of districts and postcodes NOMEALLES (Instituto de Estadística de la Comunidad de Madrid 2021) were used. Despite this adjustment, references to the variable will be made as "average income per district".

##### 4.3. Data analysis

The full analysis was carried out only on those participants who claimed to have teleworked during lockdown in Madrid (Fig. 1), either alone or with other members of the household. A descriptive analysis, stratified by gender and by quartile of average household income by district, was carried out on socio-demographic variables and housing characteristics. An analysis of the valuation and characteristics of the workspace was elaborated, and a bivariate analysis was performed by cross-checking with the socio-demographic and housing characteristics variables using the *chi-square* test. Finally, the variable rating of the telework space (1 not at all suitable, 5 totally suitable) was recoded into a dichotomous variable with the options not at all/slightly suitable (score 1 or 2) or suitable/very/totally suitable (scores 3, 4 or 5). The

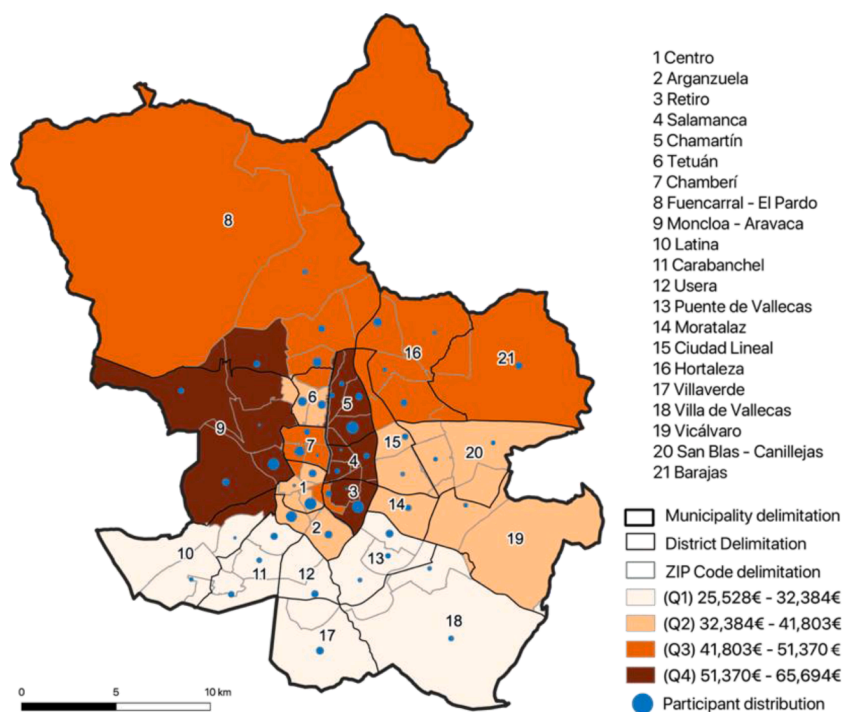


Fig. 1. Distribution of total participation in the study for the city of Madrid, by district.

relationship of these variables with the other factors was studied and the effect was adjusted for using a logistic regression model. Combinations of covariates that had shown a significant relationship with the main variable in the bivariate analysis were tested, and their interactions were explored, until the model that best fit was reached. Adjusted Odds Ratios (OR) and corresponding confidence intervals were calculated for a 95% confidence level for each variable in the model.

### 5. Results

The total population surveyed in the municipality of Madrid who responded to the questions related to teleworking was 285 participants. Of these, 10.2% (29 people) did not telework and were therefore excluded from the analysis, resulting in a sample of 256 participants.

#### 5.1. Characteristics of teleworkers in Madrid

Table 2 shows the socio-demographic characteristics of the sample of people teleworking in Madrid during COVID-19 lockdown according to gender.

Two thirds of the study population were women and 62.5% were between 35 and 54 years old. The population over 65 years of age represented only 1.2% in women and 3.6% in men. The educational level of the sample was high: 91.8% had a university or postgraduate education, with no significant differences in terms of gender. 95.7% were of Spanish origin. 85.8% of the population was employed (civil servant or not), showing a statistically significant difference between women, 91.8%, and men, 73.5%. 81.5% lived in areas with average income quartiles 2, 3 and 4 (1 being the lowest income quartile and 4 the highest). The latter was the most prevalent, with 32.7% of the sample, while quartile 1 included only 18.5%.

#### 5.2. Home features where people teleworked

Table 3 shows the characteristics and composition of the households of the teleworkers participating in the study, as well as the main variables relating to their dwellings. On average 2.5 people lived in these

Table 2  
Characteristics of people who telecommute according to gender.

Variable	Total N (% column)	Male N (% column)	Female N (% column)	p*
<b>General</b>	256 (100)	83 (32.4)	173 (67.6)	
<b>Age</b>				0.863
18-34	45 (17.6)	14 (16.9)	31 (17.9)	
35-54	167 (62.5)	56 (67.5)	111 (64.2)	
≥55	44 (17.2)	13 (15.7)	31 (17.9)	
<b>Educational level</b>				0.197
Up to High School/ Vocat.Training	21 (8.2)	9 (10.8)	12 (6.9)	
University	115 (44.9)	31 (37.3)	84 (48.6)	
Postgraduate	120 (46.9)	43 (51.8)	77 (44.5)	
<b>Job occupation</b>				<0.001
Civil servant	114 (44.9)	28 (33.7)	86 (50.3)	
Employee	104 (40.9)	33 (39.8)	71 (41.5)	
Self-employed/ Executive	36 (14.2)	22 (23.5)	14 (8.2)	
<b>Place of birth</b>				0.109
Spanish	245 (95.7)	77 (92.8)	168 (97.1)	
Foreign	11 (4.3)	6 (7.2)	5 (2.9)	
<b>Average rent per district</b>				0.447
(lower income)	46 (18.5)	11 (13.6)	35 (21.0)	
Quartile 1				
Quartile 2	69 (27.8)	26 (32.1)	43 (25.7)	
Quartile 3	52 (21.0)	18 (22.2)	34 (20.4)	
Quartile 4 (higher income)	81 (32.7)	26 (32.1)	55 (32.9)	

\* P value for the chi-square test of the relationship of the variable with gender. <0.05 implies a significant relationship.

households (SD: 1.281; Range [1-7]). .

Teleworkers in areas in the second income quartile were more likely to live alone or with a partner than those in the other income quartiles. 35.2% lived with people under 18 years of age and 10% lived with people over 65. The average floor area was 84.1 m<sup>2</sup> (SD: 35.6; Range [25-300]), which is 41m<sup>2</sup> per cohabiting person (SD: 35.6; Range [10-200]). The living area of the dwellings showed a statistically significant relationship with income level. Living in areas with higher income

**Table 3**

Characteristics of households and dwellings of people who telework (quantitative variables).

Variable	Average value	SD	Range Min/Max
Persons 0-5 y. o. in the home	0.17	0.503	0-3
Persons 6-11 y. o. in the home	0.22	0.524	0-3
Persons 12-17 y. o. in the home	0.24	0.584	0-3
Persons 18-65 y. o. in the home	1.77	0.822	0-5
Persons 65 y. o. and more in the home	0.14	0.446	0-2
Total people in the home	2.54	1.281	0-7
Useful floor area of dwelling (m <sup>2</sup> )	84.1	35.600	25-300
Useful floor area of dwelling by person (m <sup>2</sup> per inhabitant)	41.0	25.118	10-200

quartiles was associated with teleworking in homes with larger floor space, although the smallest dwellings were in quartiles 2 and 3. 64.9% of the sample owned their home, while 35.1% lived in rented accommodation. Internet access was available to 100% of the sample: 10.5% considered the digital facilities available to them to be deficient or insufficient, while 20.3% considered them to be very good. 11.7% considered the lighting in the house to be inadequate or not at all adequate, while 88.3% considered it to be adequate or very adequate. Air quality was considered good or very good by 81.4% of respondents, and the housing noise insulation was considered adequate or very adequate by 62.3%. Table 4 shows the housing characteristics of respondents who teleworked according to average income quartile by

**Table 4**

Dwelling features of respondents who teleworked, by district's average income quartiles.

Variable	Total N (% col)	First Quartile N (% col)	Second Quartile N (% col)	Third Quartile N (% col)	Fourth Quartile N (% col)	p*
<b>General</b>	248 (100)	46 (18.5)	69 (27.8)	52 (21.0)	81 (32.7)	
<b>Persons in the household</b>						0.060
One	62 (27.0)	12 (28.6)	22 (34.9)	11 (22.0)	17 (22.7)	
Two	62 (27.0)	10 (23.5)	23 (36.5)	10 (20.0)	19 (25.3)	
More than two	106 (46.1)	20 (47.6)	18 (28.6)	29 (58.0)	39 (52.0)	
<b>Live with children under 18</b>						0.136
No	149 (64.8)	24 (57.1)	47 (74.6)	28 (56.0)	50 (66.7)	
Yes	81 (35.2)	18 (42.9)	16 (25.4)	22 (44.0)	25 (33.3)	
<b>Live with people over 65</b>						0.322
No	207 (90.0)	37 (88.1)	54 (85.7)	48 (96.0)	68 (90.7)	
Yes	23 (10.0)	5 (11.9)	9 (14.3)	2 (4.0)	7 (9.3)	
<b>Useful floor area</b>						<0.001
Up to 60m <sup>2</sup>	62 (27.0)	8 (18.6)	26 (41.3)	16 (32.7)	12 (16.0)	
61-80 m <sup>2</sup>	61 (26.5)	22 (51.2)	9 (14.3)	7 (14.3)	23 (30.7)	
81-100m <sup>2</sup>	70 (30.4)	10 (23.3)	22 (34.9)	16 (32.7)	22 (29.3)	
≥100 m <sup>2</sup>	37 (16.1)	3 (7.0)	6 (9.5)	10 (20.4)	18 (24.0)	
<b>Useful floor area per person</b>						0.385
≤24m <sup>2</sup> /person	60 (26.2)	14 (33.3)	13 (20.6)	14 (28.6)	19 (25.3)	
>24-≤35m <sup>2</sup> /person	69 (30.1)	10 (23.8)	18 (28.6)	20 (40.8)	21 (28)	
>35-≤50m <sup>2</sup> /person	49 (21.4)	7 (16.7)	19 (30.2)	7 (14.3)	16 (21.3)	
≥51m <sup>2</sup> /person	51 (22.3)	11 (26.2)	13 (20.6)	8 (16.3)	19 (25.3)	
<b>Occupation of dwelling</b>						0.090
Owned	146 (64.9)	31 (77.5)	38 (62.3)	35 (71.4)	42 (56.0)	
Rented	79 (35.1)	9 (22.5)	23 (37.7)	14 (28.6)	33 (44.0)	
<b>Access to digital resources</b>						0.123
Deficient/insufficient	25 (10.5)	5 (11.4)	9 (13.4)	5(10.0)	6 (7.9)	
Enough	83 (35.0)	19 (43.2)	26 (38.8)	13 (26.0)	25 (32.9)	
Good	81 (34.2)	13 (29.5)	26 (38.8)	20 (40.0)	22 (28.9)	
Very good	48 (20.3)	7 (15.9)	6 (9.0)	12 (24.0)	23 (30.3)	
<b>Overall lighting</b>						0.686
Absolutely/ inappropriate	26 (11.7)	4 (9.5)	6 (9.8)	7 (14.3)	9 (12.9)	
Appropriate	79 (35.6)	14 (33.3)	24 (39.3)	17 (34.7)	24 (34.3)	
Very appropriate	81 (36.5)	17 (40.5)	25 (41.0)	13 (26.5)	26 (37.1)	
Totally appropriate	36 (16.2)	7 (16.7)	6 (9.8)	12 (24.5)	11 (15.7)	
<b>Air quality</b>						0.181
Very bad/Bad/Regular	41 (18.6)	8 (19.5)	6 (9.8)	10 (20.4)	17 (24.6)	
Good/Very good	179 (81.4)	33 (80.5)	55 (90.2)	39 (79.6)	52 (75.4)	
<b>Noise insulation</b>						0.405
No/little insulated	83 (37.7)	17 (41.5)	27 (43.5)	14 (28.6)	25 (36.8)	
Prop./very/totally insulated	137 (62.3)	24 (58.5)	35 (56.5)	35 (71.4)	43 (63.2)	

\* P value for the chi-square test of the relationship of the variable with the adequacy of the telework space. p <0.05 implies a statistically significant relationship.

district.

5.3. Assessment and characteristics of the workspace

The rating of the telework space, requested in the questionnaire with a Likert-type scale (scale: 1 not at all suitable - 5 totally suitable) had a mean score of 2.9 (SD: 0.985; Range [1-5] ). 33.3% rated their telework space as not very or not at all suitable (score 1 or 2) and 66.7% as suitable, very or totally suitable (scores 3-5). Rating the space as adequate or not at all was related to having a dedicated space for it, the number of people teleworking in the household, and having good characteristics of the telework area. No relationship was found with socio-economic or housing characteristics. Table 5 shows the characteristics of the telework space in relation to its rating.

Only 27% of teleworkers had a dedicated space for teleworking. The majority, 66.1%, worked in a multi-purpose space (i.e. where other actions such as eating or resting are carried out), with 46.5% of the cases being temporary (i.e. intended as a result of the lockdown). 6.5% had no fixed space at home for teleworking. Those over 55 years of age showed the highest availability of exclusive areas (40.9%), while those under 35 years of age had the least (17.1%). The useful area of the home was also significantly related to the availability of an exclusive space: the larger the useful floor area, the greater the availability of dedicated space for teleworking.

In the case of the variable average income quartile per district (p:0.292): In the first quartile (lowest income) 37.2% considered the space not or not at all suitable, in the second quartile 23.9%, in the third

**Table 5**  
Workspace features according to the perception on adequacy rating.

Variable	Total N (% col)	No or little suitable N (% row)	Suitable/very/ totally suitable N (% row)	p*
General	246 (100)	82 (33.3)	164 (66.7)	
<b>Space for teleworking</b>				
Exclusive use	67 (27.3)	2 (3.9)	65 (97.0)	<0.001
Regular multi-purpose	48 (19.6)	13 (27.1)	35 (72.9)	
Temporary multi-purpose	114 (46.5)	55 (48.2)	59 (51.8)	
Roaming space	16 (6.5)	12 (75.0)	4 (25.0)	
<b>Persons who telework</b>				
One person	98 (39.8)	24 (24.5)	74 (75.5)	0.017
Two or more persons	148 (60.2)	58 (39.2)	90 (60.8)	
<b>Daylight entrance</b>				
Not suitable	63 (25.6)	39 (61.9)	24 (38.1)	<0.001
Suitable	183 (74.4)	43 (23.5)	140 (76.5)	
<b>Room size</b>				
Not suitable	76 (30.9)	45 (59.2)	31 (40.8)	<0.001
Suitable	170 (69.1)	37 (21.8)	133 (78.2)	
<b>Room temperature</b>				
Not suitable	79 (32.1)	37 (46.8)	42 (53.2)	0.002
Suitable	167 (67.9)	45 (26.9)	122 (73.2)	
<b>Views to the outside</b>				
Not suitable	122 (49.6)	52 (42.6)	70 (57.4)	0.002
Suitable	124 (50.4)	30 (24.2)	94 (75.8)	
<b>Surface finishings</b>				
Not suitable	126 (51.2)	49 (38.9)	77 (61.1)	0.058
Suitable	120 (48.8)	33 (27.5)	87 (72.5)	
<b>Furniture</b>				
Not suitable	133 (54.1)	61 (45.9)	72 (54.1)	<0.001
Suitable	113 (45.9)	21 (18.6)	92 (81.4)	
<b>Window quality</b>				
Not suitable	141 (57.3)	55 (39.0)	86 (61.0)	0.029
Suitable	105 (42.7)	27 (25.7)	78 (74.3)	
<b>Solar control devices</b>				
Not suitable	148 (60.2)	59 (39.9)	89 (60.1)	0.008
Suitable	98 (39.8)	23 (23.59)	75 (76.5)	
<b>Noise insulation</b>				
Not suitable	162 (65.9)	61 (37.7)	101 (62.3)	0.046
Suitable	84 (34.1)	21 (25.0)	63 (75.0)	
<b>Artificial lighting availability</b>				
Not suitable	166 (67.5)	69 (41.6)	97 (58.4)	<0.001
Suitable		13 (16.3)	67 (83.8)	

**Table 5 (continued)**

Variable	Total N (% col)	No or little suitable N (% row)	Suitable/very/ totally suitable N (% row)	p*
	80 (32.5)			
<b>Space for vegetation</b>				
Not suitable	194 (78.9)	72 (37.1)	122 (62.9)	0.015
Suitable	52 (21.1)	10 (19.2)	42 (80.8)	
<b>Total of suitable aspects</b>				
Less than 5	135 (54.9)	66 (48.9)	69 (51.1)	<0.001
5 or more	111 (45.1)	16 (14.4)	95 (85.6)	

\* P value for the chi-square test of the relationship of the variable with the adequacy of the telework space. p <0.05 implies a statistically significant relationship.

quartile 35.3% and in the fourth quartile 37.7%.

Ten out of the eleven characteristics of the telework space that were asked about, were related to the assessment of the suitability of the space, with the most statistically insignificant being good surface finishes. On average, participants had 5.1 of the eleven characteristics surveyed (SD: 2.97; Range [0-11]). Having more than 5 of these positively rated features was associated with a higher rating of the suitability of the space for teleworking (85.6% compared to 51.1% of those with less than 5 of these features). Having more than 5 adequate aspects of telework space is significantly related to having a higher level of university education; to being self-employed, an entrepreneur or a civil servant; to living in houses with more useful floor area; and to owning a house. The majority of the surveyed population claims to have a space with natural lighting (74.4%) and adequate size (69.1%) and temperature (67.9%) for work. Having an adequately sized telework space is also related to having more useful floor space in the home, to home ownership, to being over 35 years of age and to living in areas in the second- or third-income quartile.

#### 5.4. Factors related to the inadequacy of the telework space

The adjusted factors that are related to rating the teleworking space as unsuitable or not suitable at all are shown in Table 6. The Odds Ratio (OR) indicates the probability that a given characteristic, such as unsuitability of the telework space, is likely to occur, taking into account the different aspects (categories of the variables) to be considered, with respect to a given one, taken as the "reference", which would be equivalent to the unit.

The factors identified as being related to the inadequacy of the telework space once adjusted for are: not having a dedicated workspace, or having a multi-purpose workspace; more than one person teleworking in the household; having poor digital facilities; having poor or inadequate home lighting; inadequate room size or furnishings; or having more than half of the workspace characteristics as inadequate. The adjusted logistic regression model has a Nagelkerke's R-square of 0.583.

## 6. Discussion

### 6.1. Discussion of findings

The above results show that teleworkers are initially in a more privileged position, being highly educated, living in areas with a higher average income, and many of them are civil servants.

Despite this, one third of teleworkers found their telework location unsuitable. This inadequacy was related to a lack of dedicated



**Table 6**  
Adjusted model of telework space inadequacy.

Variable	Adjusted OR	CI 95%
<b>Space for teleworking</b>		
Exclusive use	Ref	-
Regular multi-purpose	21.12	(3.31-134.73)
Temporary multi-purpose	30.25	(5.52-165.80)
Roaming space	47.92	(5.72-401.32)
<b>Persons who telework</b>		
One person	Ref	-
Two or more persons	3.58	(1.49-8.59)
<b>Access to digital resources</b>		
Enough/good/very good	Ref	-
Deficient/insufficient	6.98	(1.98-24.67)
<b>Overall lighting</b>		
Appropriate/Very appropriate/Totally appropriate	Ref	-
Absolutely/ a little inappropriate	10.05	(2.71-37.29)
<b>Room size</b>		
Yes, adequate	Ref	-
No, inadequate	4.38	(1.85-10.40)
<b>Furniture of telework space</b>		
Yes, adequate	Ref	-
No, inadequate	2.86	(1.25-6.54)
<b>Total of suitable aspects</b>		
Less than 5	Ref	-
5 or more	2.55	(1.08-6.00)

workspaces, be more than one teleworker per household, poor digital resources, or inadequacy of the characteristics of such spaces.

What made a home workspace more suitable, especially in the context of lockdown, mainly was: finding at least five aspects of the space suitable, such as room size, lighting, temperature, furniture, noise insulation, natural light, among others.

While these results mainly refer to the characteristics of housing and teleworking spaces, they are closely related both to aspects of the design of cities and the built environment, with their infrastructures and management policies, as well as with the socio-economic characteristics of the cities, households and their members, and their ways of life and interpersonal relationships.

### 6.2. Factors influencing teleworker's taxonomy and home workspace suitability

Regarding the socio-economic factors of the sample, these differ from the official data for the municipality of Madrid, as the population distribution shows only 38% of people aged 25 and over with university studies, compared to 91.8% of the sample captured in the study; the income is distributed differently, as it offers the average income per household of 40,195 €, corresponding to a Q2 quartile (the study would place it in a Q3). The official gender percentage is 53.38% female versus male (46.62%), with the proportion of women being higher in the study (Ayuntamiento de Madrid 2020, Instituto Nacional de Estadística 2021).

On the subject of the average income per household variable, it did not show a significant relationship with respect to most of the variables. It was only found to be related to the useful floor area of the dwelling, but not to the occupancy density (m<sup>2</sup>/person). This is in line with the idea that teleworking is an option only available to certain upper-middle social strata where the socio-cultural level is high, as well as the economic level (López-Igual and Rodríguez-Modroño, 2020).

In regard to the profile of home-based workers in the COVID-19 context, the sample in the study shows a higher proportion of women, which could be a gender bias (one of the variables used in the stratification), as the sample ratio between women and men was 2:1. There is official data relating a greater presence of women in the household during confinement, either because of teleworking (Ahrendt et al., 2020), caring for dependents, or reconciling the two (Hupkau and

Victoria, 2020). This may also respond to women's initial predisposition to stay at home if they had to look after children, the elderly, etc. (Sullivan and Lewis, 2001).

The study also highlights the level of university education of the majority, as well as the high percentage of civil servants and employees, and the fact that most households have a high level of income. These characteristics are in tune with those described in the *Eurofound Report on Life, Work and COVID-19* (Ahrendt et al., 2020). This has posed a change from the traditional teleworker model. Whereas before COVID-19, telework was largely performed by experienced and highly skilled white-collar professionals, following the pandemic, telework was also extended to less experienced and less skilled professionals. In contrast, the crisis highlighted the difficulties of remote working for blue-collar employees, due to the inability to telework by the very nature of the job tasks (Sostero et al., 2020). This would explain the lack of respondents in the survey of less educated people. According to *Eurofound's COVID-19 e-survey*, participants who teleworked were characterised by a high educational and economic level, considering themselves privileged to be able to work from home in a safe way, avoiding physical contact and therefore the spread of disease (Ahrendt et al., 2020).

Likewise, this reasoning could justify the lack of relationship between the average income level of the district and the occupancy regime, the availability of digital resources, or aspects of indoor environmental quality such as lighting, air quality, or noise insulation, the latter associated with aspects such as the quality of the buildings and their age (España 2020, Caro and Sendra, Jan. 2020). This would explain that for the sample, aspects such as the main characteristics of the dwellings (useful area, number of rooms, or tenure, among others), as well as the composition of the household, do not seem to influence the perception of the suitability of teleworking.

### 6.3. Implications of teleworking for people's lives

As for the advantages of teleworking, there are studies that list some (Tavares, 2017), of a personal nature or affecting the home. In this sense, those that study gender (Hupkau and Victoria, 2020) stand out, noting how it affects women, together with family reconciliation and the care of dependents, including children. Some studies highlight improvements in productivity and satisfaction (Kazekami, Mar. 2020), although there does not seem to be unanimity in this regard, with other studies claiming that women spent more time on care and reported lower productivity and job satisfaction than men (Feng and Savani, 2020).

Nevertheless, to do this, minimum conditions for teleworking would have to be ensured, such as guaranteed energy and internet supply, minimum digital resources, housing, and environmental conditions of the space, as well as ergonomic furniture, agreed between company and worker, and properly regulated (Ahrendt et al., 2020). This could not be done during the lockdown, since the measure was applied urgently, and rather as an "experiment" (Cuervo-Vilches, Navas-Martín, & Oteiza, 2021): with the dependents at home, without agreements with companies, without adequate equipment, or arrangements for the payment of supplies.

According to similar studies (Liu et al., Jul. 2021, de Frutos et al., Jul. 2021), the COVID-19 pandemic has affected differently to the population groups, related to their occupation activities and their nature. For this reason, dwelling activity has not clearly been increased, because enough data has not been obtained. The reported population movements nationwide difficult the contagion control, and proofs a lower urban resilience. Nevertheless, a relevant decrease in energy consumption by activity sectors has been a general characteristic in cities (Zhang et al., Oct. 2021).

The online activity has been generally increased, with an important teleworkers' growth worldwide (Mouratidis and Papagiannakis, Nov. 2021), as well as the rising usage of digital devices (Jaimes Torres et al., Jun. 2021), affected once again by human factors, and the response of

urban management. Connectivity fortresses not only smart but also healthier cities (Yang and Chong, Jul. 2021), but depends on their population size, and the reluctance of industries, especially in certain sectors, such as construction (Ebekezi and Aigbavboa, Jun. 2021).

Socio-economic factors primarily affect the spread of the pandemic (Liu et al., Jul. 2021). Geographical distribution of population and mobility has been deeply analyzed due to the COVID-19 transmission (Kutela et al., Apr. 2021). Also, urbanization features show a significant relation with the spread of COVID-19. Indeed, high density cities with a higher intra-mobility in times of pandemic, increase significantly the health system pressure by higher contagion rates. Therefore, a well-designed built environment, involving not only housing but also urban open spaces and green areas, will lead to healthier cities (Maiti et al., May 2021, Viezzer and Biondi, Jun. 2021), also supported in policies and strategies to prevent mobility and thus, contagion (Li et al., Mar. 2021), such as teleworking.

In view of this, the re-evaluation and improvement of teleworking conditions through the application and/or adaptation of regulations is proposed, not only at the level of the employee-employer relationship, or the prevention of occupational hazards, but also from the specific regulations of housing, to apply minimum conditions of habitability, comfort, and equipment, accepting teleworking as a new task to be assumed by the dwelling (Cuervo-Vilches et al., Dec. 2020).

#### 6.4. Implications of teleworking for sustainability issues

The lockdown has provided some relief to outdoor air quality, at least during its validity period (Benchrif et al., Nov. 2021). At the environmental level, telework brings undoubted advantages, linked to a move away from large cities, and more presence in intermediate cities, or rural towns (Moeckel et al., 2020), which could also attract more service provision to the latter. This would furthermore improve interpersonal relations and the dedication to family, leisure and free time, as it would save on commuting times (Eldér, Jun. 2020), significant fuel savings (Moeckel, 2017), and the consequent associated emissions and pollution reduction, making cities more liveable (Abellán, Aceituno, Allende, & Andrés, 2021; Bojovic, Benavides, & Soret). Without leaving big cities, teleworking could lead to less commuting, promoting healthy and sustainable mobility (Wang and Ozbilen, Dec. 2020), and the link with local activity, which would not only ameliorate the economy of small businesses, but also enhance urban schemes such as the 15-minute city (Everett, 2020). Promoting teleworking would prevent moving away from compact or high-density cities, if public health measures are followed properly. Compact cities in times of pandemic improve the outdoor air quality and, at medium-long term, contribute to mitigate climate change (Khavarian-Garmsir et al., Jul. 2021).

Teleworking could therefore change not only the pattern of life of individuals and their households, but could revive areas through repopulation, which may also change the pattern of the housing market, benefiting both small towns and large cities and the rents demanded to live in them (Weber et al., 2020).

#### 6.5. Limitations and future research

As for the selection of the sample, the use of the online form itself, which was widely used during lockdown, limited participation to those who had an internet connection and digital resources to answer the form. These same requirements would be necessary for teleworking, so this would explain the high participation of teleworkers (although the online form of the survey allowed the use of other media, such as mobiles or tablets). This provides a great added value of this study in describing the teleworker community in this city, as well as in their perception of the telework spaces in their homes. And, therefore, the taxonomy of both these people and their homes reveals important features attributable to this new modality of work, at least in the population context considered, during lockdown.

The use of the online questionnaire in scientific research studies has increased in recent decades and has particularly skyrocketed during the general lockdown and the COVID-19 pandemic (Geldsetzer, 2020; Górnicka, Drywień, Zielinska, & Hamulka; Grover; Kar, Kar, & Kar; Muñoz-González, Ruiz-Jaramillo, Cuervo-Vilches, & Joyanes-Díaz, 2021; Muto, Yamamoto, Nagasu, Tanaka, & Wada). Although some limitations on participation biases have been discussed, it has proven to be a highly effective tool to obtain information quickly. Dissemination of the questionnaire through multiple social networks helps in this regard. In our study, it was particularly effective due to the opportunity and urgency that the moment of the general confinement entailed and especially for this job, since the teleworker population presumably has less access difficulties to answer online questionnaires than the general population, because they all have internet access at home (Ali et al., May 2020, Buchanan and Hvizdak, Jun. 2009).

Focusing the sample on Madrid allowed us to link our data to information on average income per household per district, which added the socioeconomic dimension to our analysis. This decision compromised the size of our sample. Even so, the sample is large enough to reach a precision of 6% for the determination of a proportion assuming the maximum indeterminacy ( $p = q = 0.5$ ) with a 95% confidence level. Furthermore, even with the wide confidence intervals of the OR values, 7 factors demonstrated an effect with the study variable. Although the sample size could have compromised the entry of other effects into the models, it has been sufficient to guarantee all the results presented with an acceptable level of confidence.

This study contributes to expand the telework as a labor modality giving spatial and functional keys to reach a suitable workspace in the homes, as well as a socio-economic taxonomy of teleworkers, especially under the lived extreme situation. With this aim, more experimental studies on telework will arise, that may reach representative samples at urban, regional, national and supranational levels, with research more focused on teleworker's profiles, home workspace design and features. Also, the offered teleworker's taxonomy gives valuable information for decision-makers and organizations, in order to find strategies and policies to spread telework among the population in the best conditions and overcoming the limitations and barriers detected.

Similarly, tele-study spaces should be the object of study, adapted to the needs of children, adolescents and young adults, both in habitual situations, and especially in confinement as lived by COVID-19, where in many cases teaching became virtual (Cuervo-Vilches and Navas-Martín, May 2021).

## 7. Conclusion

This study contributes to describe the taxonomy of teleworkers, including their household and dwelling characteristics. Main socio-economic features according to income quartiles by urban district were desglosed. Also, a detailed description of the workspace features was made, related to the perceived adequacy of such workspace. Finally, factors linked to inadequacy of workspaces were shown. As first conclusion, the characteristics of the telework area itself have had the greatest influence on their assessment. Likewise, not finding significant relationships with the socio-economic factors of the participating households, nor with the characteristics of their homes, it leads to a second conclusion, related to the privileged status of teleworkers in the context of COVID-19 lockdown.

This study also contributes to the knowledge about the adequacy of homes to telework requirements, according to dwelling features, household composition and incomes. This topic has been missed in most of COVID-19 research studies on telework, and even before this pandemic, due to a lack of representative samples of home workspaces, and therefore, research on their features and suitability.

Taking into account that, before the confinement by COVID-19, teleworking was accepted unevenly by nations, not without generating in most of them controversy between directors, managers and workers

(Hynes, Sep. 2016). Nowadays, this pandemic seems to offer a chance to set up this working model, specially, in certain European countries such as Spain. This contribution is useful not only in the context of lockdown, but also looking at future similar situations, and in general to boost telework in safe and comfortable terms, considering the minimal conditions to achieve the adequacy, valued by the teleworkers themselves.

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## Declaration of Competing Interest

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

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