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The Grass Is Always Greener on My Side: A Field Experiment Examining the Home Halo Effect

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Abstract: Wood-burning pollution is a severe problem in southern Chile, where every winter, people are exposed to unhealthy ambient fine particulate matter ($PM_{2.5}$) concentrations. Urban air quality is a major concern for health officials, but public awareness campaigns tend to focus on outdoor hazards. Our understanding of how residents are exposed and perceive air pollution risks in their homes remains incomplete. This study explores the ability of participants to perceive indoor air quality. We collected data on 81 households, combining perceptions of air quality with objective measurements of $PM_{2.5}$. Residents' evaluations of air quality were systematically compared to inspectors' evaluations in order to examine the home halo effect. We found that residents tended to overestimate air quality in their homes. We discuss how our data supported the existence of a home halo effect, but also point out the possibility that individuals' ability to perceive air quality in indoor spaces is limited by other factors.

Keywords: indoor air quality; public perceptions; air pollution; wood smoke; energy transitions

1. Introduction

Worldwide, ambient air pollution is estimated to cause 8.9 million premature deaths [1]. Formed by microscopic droplets, $PM_{2.5}$ can be easily inhaled, causing serious health problems [2]. Substantial research documents the association between $PM_{2.5}$ and health, including respiratory diseases [3,4], cardiovascular diseases [5,6], neurocognitive diseases [7], and pregnancy outcomes [8]. Research also shows that air pollution may induce other social problems, such as increased suicide rates [9–11], school absenteeism [12,13], and reduced work productivity [14,15]. Air pollution also tends to interact with previous socioeconomic disparities [16]. A large body of literature has found that vulnerable communities are disproportionately exposed to potentially hazardous outdoor conditions near their residents, including air quality [17].

The quality of indoor residential air and the surrounding environment may also have serious consequences on human health and well-being [18–21]. People tend to spend more than 80% of their time in indoor spaces. Indoor air pollution from the combustion of solid fuels has been associated with many diseases in the Global South, such as respiratory and middle ear infections, asthma, perinatal conditions, low birth weight, and cataracts [18,22,23]. In an uncertain future, where confinement could be used as a public health tool to control infectious diseases, this situation could worsen. However, indoor residential environmental quality has traditionally been a relatively underappreciated issue [19].

Addressing indoor exposures in medium- and low-income countries is a necessary but challenging task. Household air quality depends on a variety of factors. For example, residential indoor exposures may be influenced by variables that are socioeconomically patterned [24], by institutional factors that define housing quality [25], and by other contextual factors related to neighborhood attributes [26]. In urban southern Chile, most families have difficulties finding alternatives to wood-burning stoves for heating or cooking. Central and local governments are attempting to deal with air pollution in several ways, including measures such as replacement programs, refurbishment subsides, or prohibition of firewood usage during certain critical periods. Despite such efforts, outdoor and indoor air pollution persist in this region, having seven of the most polluted cities of Latin America [27].

Understanding how residents perceive air quality in their homes is key to better orienting their health-protective behaviors. Unfortunately, few efforts have been devoted to simultaneously analyzing indoor environmental conditions and residents' perceptions. In this study, we examined perceptions of indoor air quality in a sample of households in southern Chile and compared them with objective measurements of indoor particulate matter levels ($PM_{2.5}$). We specifically examined, first, how residents' evaluation of indoor air quality compared to measurements derived from on-site sensors. Second, we compared residents' evaluations of indoor air quality with evaluations made by inspectors. The hypothesis of the study was that residents tend to overestimate the air quality in their residences, a process that we might call a "home halo effect."

Literature

Early research into the public perception of urban air pollution adopted the "deficit" model to explain the tendency of "lay" misperceptions to diverge from actual air quality measures [19,28,29]. This means that the differences between a city's objective and perceived pollution levels were attributed to ignorance of the actual quality of the air by the general public [30–32].

More recent social science research has studied the role of a range of social factors, such as values, sex, race, age, income, emotions, stigma, and several cognitive biases in shaping perceptions of air pollution. For instance, studies have shown that concern about pollution tends to be higher among women [33–35]. Age seems to be associated with air pollution perception in a non-consistent way [36–39]. Kim, Hi, and Kim [40] have discovered higher levels of air pollution perception among young people. Forsberg, Stjernberg, and Wall [41] and Williams and McCrae [42] have indicated that middle-aged people are more sensitive to air pollution risks. A recent study in southern Chile showed that older adult women perceive the health risk of woodsmoke as less severe [39]. Several studies have found that individuals with higher levels of income and education tend to be more concerned about the impacts of air pollution on their health and largely tend to support mitigation policies [43–45]. Conversely, other works have found that ethnic minorities living in transient, urban, and poor communities may perceive greater health risks associated with outdoor air pollution [33,46,47]. People more sensitive to air pollution may have higher levels of concern [44,48]. Wells, Dearborn, and Jackson [49] observed that individuals with respiratory diseases were more likely to change outdoor activities when they perceived bad air quality.

In the past, the sensory evaluation of indoor air quality has been mainly studied from the engineering field with laboratory studies [50]. For instance, Fang, Clausen, and Fanger [51] found a significant impact of temperature and humidity on air quality perception. Participants perceived the indoor air as less acceptable with increasing temperature and humidity. These findings have been applied to determine current ventilation standards [52] and appropriate building materials [53,54]. While previous research has reported vital insights to identify sensorial mechanisms that influence indoor air perception, only a few studies have explicitly considered how households perceive and assess indoor air quality in everyday life conditions. For this reason, traditional research on indoor air has not been entirely successful at isolating problems of misperceptions that are socially rooted. There are some notable exceptions, such as the study of Langer et al. [55], where the indoor air perception was addressed with a nationwide survey of 567 French dwellings. A significant difference between visitors and residents was found (i.e., residents perceive that the air quality of their dwellings is better compared to the perception of visitors). However, other studies have only focused on residents, which represents a bias [56–59].

In fact, the relationship between objective air pollution exposure (indoors or outdoors) and subjective evaluation is also unclear. Several studies have observed associations between objective and subjective air quality measures [60–63], while others have not [64–67]. Historically, urban sociologists, geographers, and social psychologists have treated differences between objective and perceived measures as a way to understand shared cultural biases. Objective measures of air quality exposure are developed using automated methods. This has enabled researchers to identify heuristics that can influence the individual perception of air pollution. In particular, air quality has provided an interesting opportunity to study both "stigma theories" and the "halo effect."

A neighborhood stigma effect is produced when respondents associate a social trait with a social behavior or outcome, associating higher values with the behavior or outcome in communities where the trait is prevalent [67]. Thus, it is possible that an objective improvement in the physical conditions in a minority community does not necessarily imply a change in the negative perception of this community. King [65] applied the neighborhood stigma framework to examine residents' perceptions of air quality in Chicago, USA. Consistent with the stigma narrative, her research showed that air quality was rated worse where minorities and poverty were concentrated, even after controlling for objective air pollution [65].

On the other hand, one of the most studied intuitive biases in the field of air pollution perceptions is the "neighborhood halo effect." The halo effect is usually produced when an observer's overall impression of a person, place, or object influences the observer's thoughts about that entity's properties [68]. Halo effects can be explained by the theory of "bounded rationality," which refers to our limited capacity to make wise choices, even when we have the necessary information to make good decisions [69]. Several studies have found that people tend to attribute a good level of air quality to their home area in comparison to other areas [48,63]. This might produce a false sense of personal invulnerability. In a sense, individuals are able to recognize the existence of a problem in their city, but they deny that it can endanger them. This denial can be interpreted as a cognitive effort to lessen the unpleasant emotion caused by an uncontrollable environmental stressor. However, it can also be dangerous if it stops a person from trying to cope with a threat like air pollution, where further efforts to gain information or exert control might be necessary.

Although the neighborhood halo effect is considered one of the oldest and most widely identified psychological biases affecting air quality perception [70], little is known about its application to indoor spaces. A recent stream of literature points out that the "neighborhood halo effect" also extends to the home, where people tend to overestimate ambient conditions [48]. However, this misperception can be explained by alternative psychological or cultural mechanisms. The literature to date on the home halo effect is limited in providing a clear picture of the strength of the phenomenon. Demonstrating that positive global home evaluations can alter perceptions of indoor environmental quality (e.g., air quality, thermic comfort, or noise) requires further detailed investigation.

2. Materials and Methods

2.1. Local Setting

The cities of Temuco and Padre Las Casas are located in the south-central area of Chile in the Araucanía region. These two cities are placed next to each other, being separated only by a bridge over the Cautín River. Thus, even if both cities have different administrations, they are usually considered as a single city. Together, Temuco and Padre Las Casas have about 350,000 inhabitants, making it one of the largest conurbations in southern Chile. Regarding their climate conditions, this zone is characterized as having low temperatures during winter months, regularly dropping below 0 °C, in addition to windy and rainy periods in between. These climatic conditions generate a strong need for heating among Temuco and Padre Las Casas inhabitants, which is primarily covered by firewood.

Air pollution is the most visible environmental problem in both cities. The deterioration of urban air quality in southern Chile relates to the common household practice of burning wood for heating and cooking [45,71]. The affordability and availability of wood compared to other fuel substitutes explain why these energy practices are widespread in the region.

Unlike other countries in the Global South, in southern Chile, wood-burning stoves are not usually open, and there is a wide range of technological options. Nevertheless, previous studies have shown that in Temuco and Padre Las Casas, indoor and outdoor pollution levels can be very similar [25,66]. Due to the vulnerability of many of the houses in the city, high levels of infiltration have been detected, which explains the high correlation between outdoor and indoor pollution levels [25,72]. During the winter when this study was conducted, 67 critical episodes were recorded [73], i.e., for 63% of the winter days with good weather, the mean $PM_{2.5}$ values for 24 h were greater than 50 μg/m^3, the limit established by Chilean law.

2.2. Air Quality Sensor Design and Implementation

For indoor air pollution ($PM_{2.5}$) and temperature (°C) measurements, the research team created 12 small devices (see Figure 1). The following components were used for its construction: an Arduino UNO microcontroller (Arduino ltd. Boston, Massachussetts, USA) with an Secure Digital (SD) card to store data and a 16 × 2 Liquid Cristal Display (LCD) for visualization, a real-time clock (RTC DS3231, Maxim Integrated, San Jose, CA, USA), and particulate matter (Nova SDS011, Geekcreit ltd. Bejin, China), temperature (DS18B20 with external cover, Maxim Integrated, San Jose, California, USA), and humidity (DHT11, Aosong Electronics Co., ldt., Guangzhou, China) sensors. The SDS011 sensor has been widely used as a low-cost option to measure air pollution in urban areas, showing acceptable reliability levels in indoor environments, especially regarding $PM_{2.5}$ measures in high-pollution environments [74,75]. The SDS011 laser scattering detects the concentrations of particles between 0.3 to 10 μm in size in the air with a resolution of 0.3 μg/m^3 and a relative error of 10% [76]. This sensor works in an environment with humidity up to 70%, which is suitable for indoor measurements. In addition, reliability tests were performed to verify that all devices reported similar measures when they were switched on simultaneously.

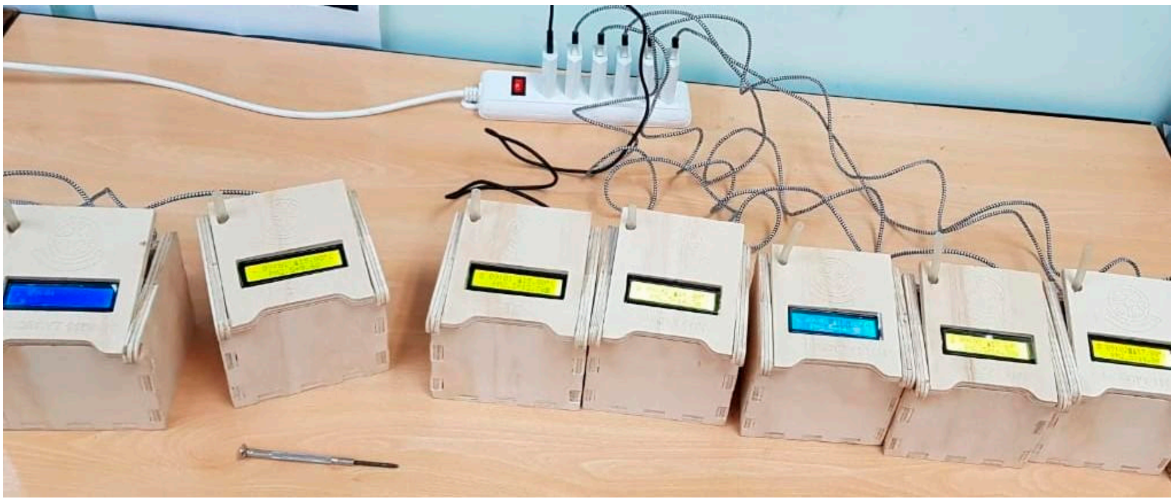

Figure 1. Devices to measure indoor fine particulate matter ($PM_{2.5}$).

The device was installed not showing any information to the participants, with the aim of studying their natural perception about the amount of particulate matter inside their home. The LCD display of the sensor only showed the date and time, which allowed people at home to use the device as a wall clock and know whether the device was working. Internally, and for the purpose of later analysis, the device recorded the information every 5 min on an SD card, including the following fields: date, time, $PM_{2.5}$ (μg/m^3), PM_{10} (μg/m^3), temperature (°C), and humidity (%). Thus, data were grouped by hour to compute the mean and standard deviation.

2.3. Measurements and Experimental Procedure

Ten pairs of inspectors visited different houses in Temuco and Padre Las Casas from 6 August to 11 September 2019. All inspectors went through a training process where they were taught about how to correctly use and install the $PM_{2.5}$ sensors. They were also informed, in broad strokes, about the situation in Temuco and Padre Las Casas regarding air pollution such that all of them had a common knowledge on the subject. For this purpose, all the inspectors met in a room with the research team, who showed them a 5-min presentation about these cities' air quality. Each inspector was able to evaluate a maximum of 10 houses in order to avoid a learning effect regarding the assessment of pollution, both inside and outside homes. Furthermore, it should be noted that the pairs of inspectors were not fixed, but were formed according to their availability. This helped to increase the variability of the evaluations performed.

Once the inspectors arrived at the participant's house, they immediately answered a short five-item questionnaire (see Supplementary Materials) to evaluate the indoor air quality on a nine-point Likert scale (ranging from 1—very bad to 9—very good), as well as the outdoor air quality (neighborhood and city) at that moment. Participants were asked to indicate their address and the time at which they answer the questionnaire. Completing the questionnaire took about two minutes. After this, the participants answered an extended version of this questionnaire with 25 questions (see Supplementary Materials), where they rated the outdoor and indoor air quality levels, both in general and on that specific day. The other questions they answered were about the severity of air pollution (five-point Likert scale ranging from 1—not dangerous to 5—very dangerous) and their level of concern for its effects in their health (five-point Likert scale ranging from 1—not worried to 5—very worried), as well as sociodemographic questions, such as gender, age, education level, profession, family income, and whether any member of the household smoked or had a disease. The questionnaire also contained questions about the home characteristics, such as the year of construction, square meters, number of rooms, main construction material, and other aspects regarding the thermal insulation. This was answered by the head of the household, along with other adult household members (e.g., spouse). Answering this questionnaire took approximately 5 min. Perception questionnaires were filled out before the air quality measurements, rather than during or after monitoring, which was done to avoid the "Hawthorne Effect": the potential tendency of our participants to modify some aspects of their behavior in response to their awareness of being monitored by the sensor.

After getting this information, the inspectors installed the air quality sensor in order to take indoor data about the temperature and pollution levels ($PM_{2.5}$). To protect the integrity and proper functioning of the sensors, participants were asked not to manipulate them. Furthermore, following the procedures of previous studies [66,71,77], the sensors were installed in living rooms a minimum of two meters away from the wood-burning stoves and safely out of the reach of children, pets, or other factors that could alter their functioning. Given that the sensor was near the stove, its data can be considered the maximum household temperature. This way, the sensors collected data passively, without offering information to users for a 24 h period. Finally, the inspector came back to uninstall the sensor and continue with the next house.

After this process, the indoor temperature and pollution data were extracted from the sensors. In addition, the city's pollution data were obtained through the National Air Quality Information System (SINCA in Spanish) [78]. The purpose of this process was to contrast objective measures, both indoors and outdoors, with the subjective perception of both the residents and inspectors (non-residents) who evaluated this aspect.

2.4. Participants

This study was carried out in 81 homes in Temuco and Padre Las Casas (see Figure 2), selected through non-probability sampling by convenience. In each home, two inspectors and the head of the household answered the questionnaire, plus another household member in some cases. This gave us a total of 280 participants. The households were selected with a deliberate criterion for balance according to demographic and socioeconomic variables: age, gender, income, and education level. The aim was to reflect the variety of situations in which different types of families can interact with indoor air pollution.

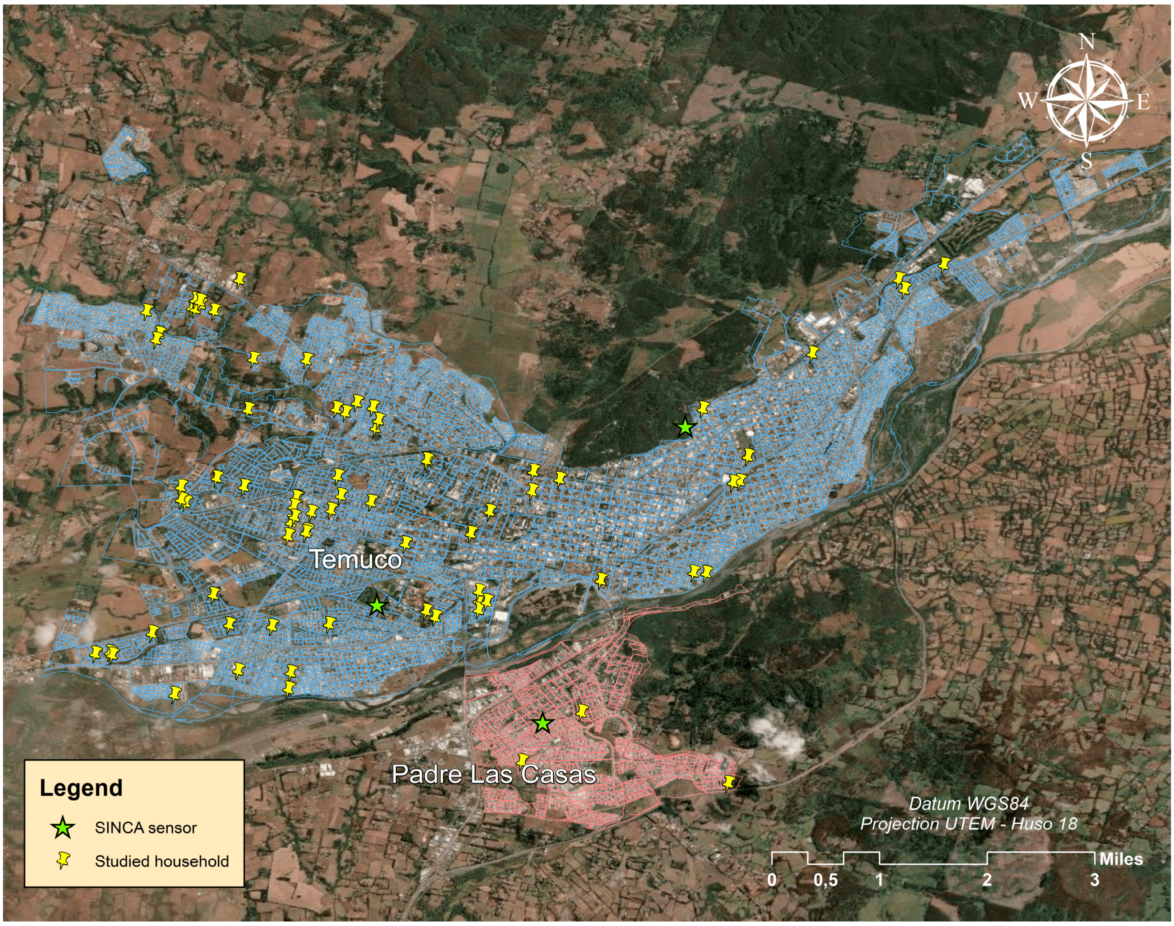

Figure 2. Sample's geographical distribution.

The average age of the residents participating in the study (n = 118) was 38.23 years (SD = 16.18), where 57.6% were men and 42.2% were women. With respect to the education level of the residents, 28.8% had completed high school or less, 42.4% achieved incomplete university studies, and 28.8% achieved complete university studies. On the other hand, the average age of the inspectors (n = 21) was 25.67 years (SD = 5.96), where 42.9% were men and 57.1% were women. All the non-residents had university studies or higher.

In Appendix A, Table A1 provides details of the general characteristics of the participants' houses, including the year of construction, square meters, presence of double-pane windows, and heating system. Additionally, other aspects are presented, such as household income, the presence of minors, older adults, people with a disease, or smokers in the home.

2.5. Data Analysis

First, the data from the sensors were cleaned, eliminating cases with defective or incomplete measurements. Then, descriptive statistics were used for the indoor $PM_{2.5}$ per hour and overall data. This data was complemented by external outdoor measurements of $PM_{2.5}$ obtained through SINCA [78]. The review of the assumption of normality of the study variables using the Kolmogorov–Smirnov test ($p > 0.05$) indicated that the variables did not distribute normally; therefore, non-parametric tests were used. For the comparison of two independent groups, the Mann–Whitney U test was used. Means and standard deviations were reported to facilitate the reading and interpretation of the data. On the other hand, Spearman correlations (ρ) were performed as a non-parametric Pearson alternative to measure the relationship between the variables. We used SPSS v.25 (IBM Corp., Armonk, N.Y., USA) for most of the study analysis.

To contrast the hypothesis of the halo effect, a dummy variable was constructed in order to identify those participants who overestimated the air quality of their home. In the study, we classified as overestimation those situations where the participants considered that the air quality of their home was good but the sensors recorded average $PM_{2.5}$ levels > 25 μg/m^3 in the previous 24 h, a measurement the WHO considers unhealthy for short exposures [79]. Finally, the probability of overestimation was compared between residents and non-residents to understand the extent to which this bias was due to a possible home halo effect.

3. Results

3.1. Relationship Between Outdoor and Indoor Air Quality

Before examining the differences between residents' evaluation of air quality and objective measurements of indoor air quality, we measured both indoor and outdoor air quality at the study participants' residences. Figure 3 shows that there was a direct and strong correlation between the $PM_{2.5}$ inside and outside the home ($\rho = 0.714$, $p < 0.001$). Overall, indoor $PM_{2.5}$ levels reported by the sensor were relatively high in the study residences, with a daily mean of 33.07 μg/m^3 (SD = 26.28) and reaching peaks up to 144.61 μg/m^3. Outdoor $PM_{2.5}$ levels in the period in which the experiments were conducted reached peaks of 74 μg/m^3, with a mean of 35.37 (SD = 18.25), according to MMA records. Both cases exceeded the healthy levels recommended by the WHO of ≥25 μg/m^3 per day.

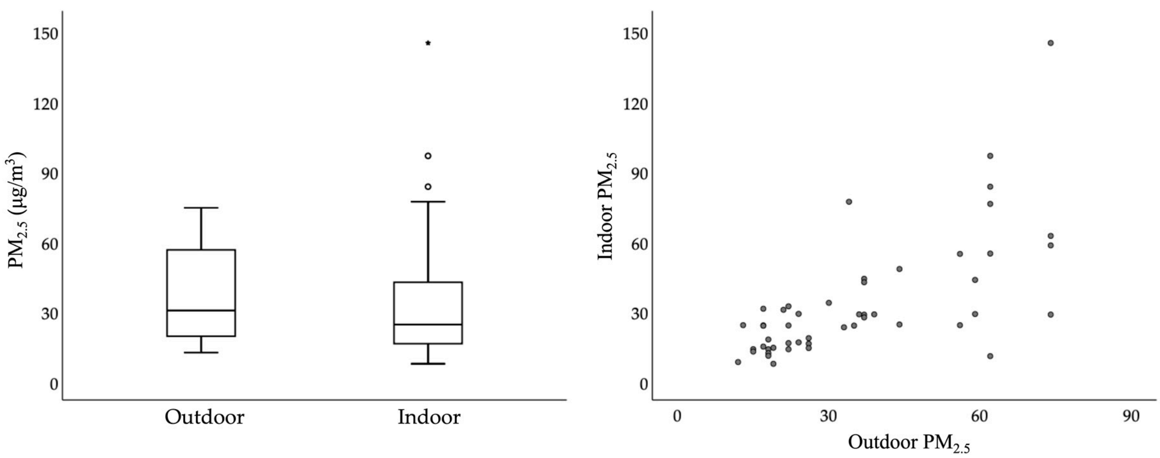

Figure 3. Average outdoor and indoor $PM_{2.5}$ level.

Figure 4 shows the boxplots of the outdoor and indoor $PM_{2.5}$ concentrations depicting the hourly variability of data. Results show that the means of the indoor and outdoor air pollution followed very similar patterns and varied in terms of the activity in the home. In both cases, the $PM_{2.5}$ concentration levels were higher between 6 p.m. and 12 p.m. (local time) when cooking and heating were frequent indoor activities.

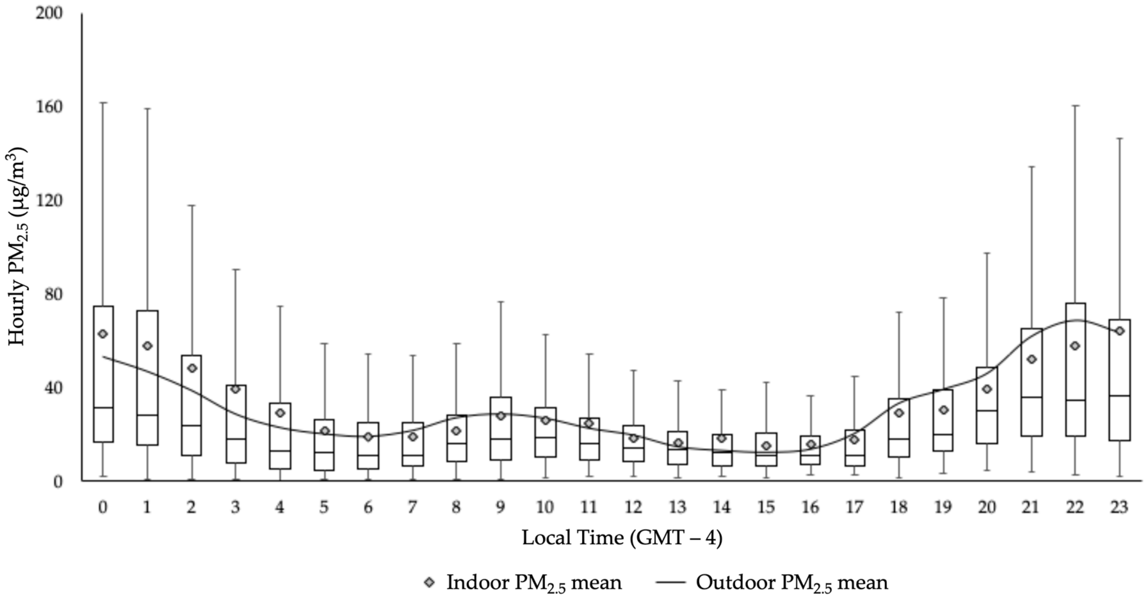

Figure 4. Hourly indoor and outdoor $PM_{2.5}$ levels.

3.2. Participants' Evaluations of Indoor and Outdoor Air Quality and Objective Measures

As shown in Figure 5, the study participants tended to provide a more positive evaluation of the indoor air quality relative to the outdoor air quality (city and neighborhood level), either on the day of measurement or in general. On a scale from 1 to 9, the average evaluation of the general air quality was 6.26 (SD = 1.98) for indoor air quality, 3.97 (SD = 1.90) for outdoor neighborhood air quality, and 3.25 (SD = 1.96) for the city.

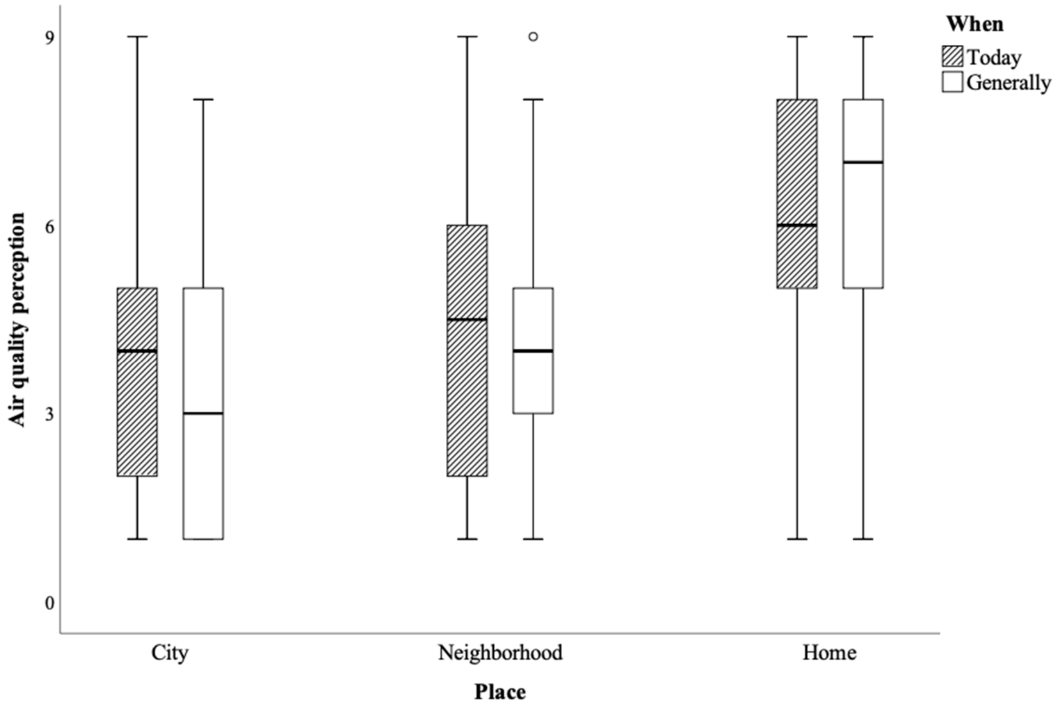

Figure 5. Participants' perception of air quality today (measurement day) and in general.

No significant correlation between the outdoor and indoor $PM_{2.5}$ levels and the participants' perceptions was found, either for outdoors ($p = 0.713$) or indoors ($p = 0.505$). However, in order to better compare the participants' subjective evaluations of indoor air quality with objective measures derived from the in-home sensors, we first classified the average $PM_{2.5}$ values for 24 h as either healthy (≤25 μg/m^3) or unhealthy (>25 μg/m^3) following the criteria of the WHO [79]. Table 1 shows that 75.30% of the participants with unhealthy levels of indoor $PM_{2.5}$ overestimated their indoor air quality. This means that only one of every four participants rated poor indoor air quality as bad. The percentages were very similar independent of the actual indoor air pollution levels, showing that residents' evaluations of the indoor air quality were somehow independent of the actual levels of air quality and that residents tended to overestimate the indoor levels of air quality. Overestimation was higher for indoor air quality relative to outdoor air quality.

Table 1. Interaction between subjective perception and objective measures of air quality.

$PM_{2.5}$ location	**Air Healthiness**	**Participant's Air Quality Perception**	
		Bad	**Good**
		***n* (%)**	***n* (%)**
Outdoor	Unhealthy (>25 μg/m^3)	81 (54.36)	68 (45.63)
	Healthy (≤25 μg/m^3)	56 (46.66)	64 (53.33)
Indoor	Unhealthy (>25 μg/m^3)	20 (24.69)	61 (75.30)
	Healthy (≤25 μg/m^3)	21 (24.70)	64 (75.29)

3.3. Residents' and Inspectors' Evaluations of the Indoor Air Quality

Finally, we compared the subjective evaluation of air quality provided by residents and inspectors. As shown in Table 2, there were significant differences between residents and non-residents. Compared to the inspectors, residents tended to evaluate the air quality indoors in a more positive note ($\chi^2 = 7235.00$, $p = 0.001$). On the contrary, residents tended to evaluate the air quality outdoors in a more negative note, relative to the inspectors ($\chi^2 = 7010.00$, $p < 0.001$; $\chi^2 = 8392.50$, $p = 0.109$).

Table 2. Difference between inspectors' and occupants' perceptions.

Variables	**Residents**	**Non-Residents**	χ^2
	M (SD)	**M (SD)**	
Today's city air quality	3.83 (2.13)	4.72 (1.48)	7010.00 ***
Today's neighborhood air quality	4.33 (2.19)	4.77 (1.51)	8392.50
Today's home air quality	6.08 (2.05)	5.43 (1.72)	7235.00 **

Note: ** $p < 0.01$, *** $p < 0.001$.

4. Discussion

Our study yielded several interesting and novel results. First, and consistent with previous findings, we discovered that the concentration of particulate matter in the residences of our study participants was strongly associated with outdoor pollution levels. Second, the results of our investigation showed that both residents and non-residents had difficulties in adequately evaluating the environmental conditions in indoor spaces. Residents tended to evaluate indoor air quality as healthier than what the data from the sensors showed, and they also tended to evaluate air quality as more positive relative to inspectors.

Previous research suggests that public lay misperceptions of indoor air quality could depend on several factors [55,66]. The main aim of our study was to identify the presence of a possible home halo effect and analyze the extent to which this effect could be biasing the perception of air quality in a sample of residents in urban southern Chile. Our findings showed that the home halo effect existed:

individuals tended to overestimate the indoor residential environmental quality in their own homes. However, the difference in terms of the subjective evaluation of air quality between residents and inspectors was moderate, and non-residents also tended to assess the air quality as more positive compared to the actual air pollution levels in the monitored homes, although not to the extent that the residents did (see Figure 6). Following previous literature, three mechanisms could be used to explain this general overestimation, together with the home halo effect: (i) sensory capacity, (ii) habituation, and (iii) media coverage.

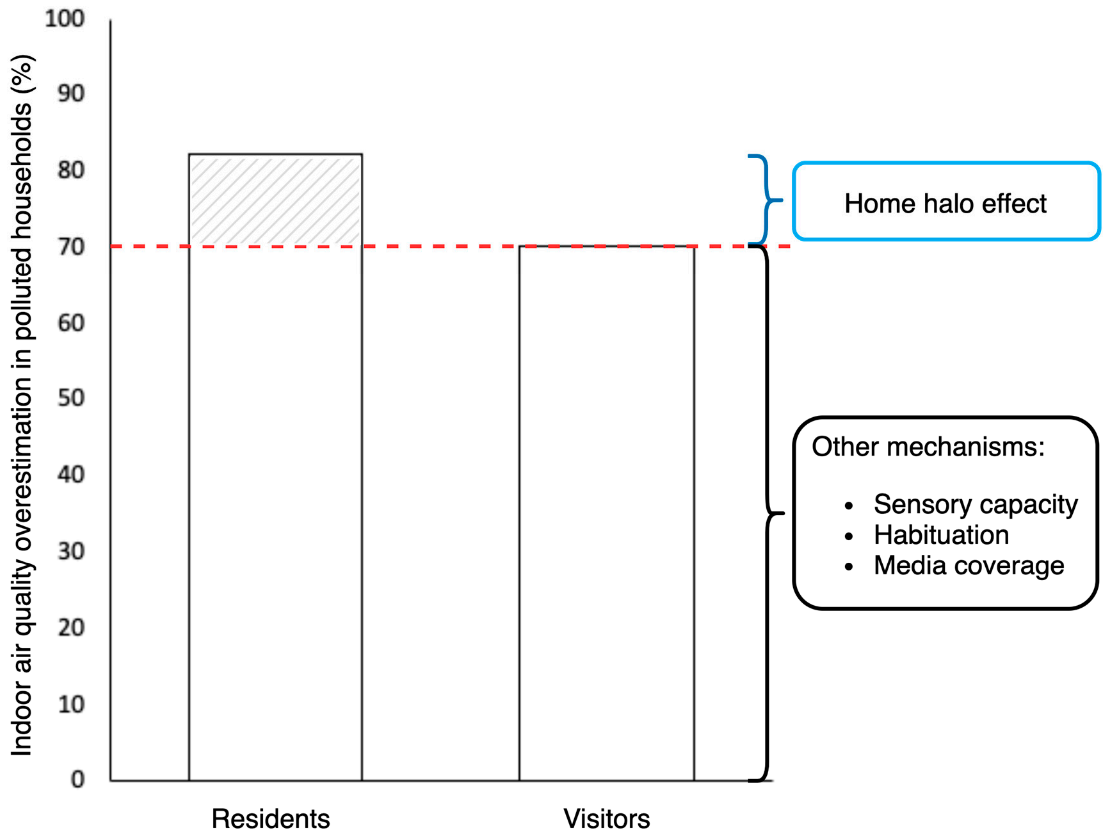

Figure 6. Residents' and visitors' indoor air quality overestimation in polluted households (>25 μg/m^3/24 h).

Over the last two decades, socio-cultural approaches to air pollution risk perception have situated the everyday understanding of this environmental problem within a wide social, cultural, and political analysis [17]. Practical everyday experience is especially relevant, given that air pollution perceptions tend to be embedded in daily life through the senses and the body. Outdoor wood smoke is very visible during the frequent critical episodes in winter in southern Chile. People are used to going out to buy bread for dinner and finding the streets blanketed with smoke from wood-burning stoves, and returning home with their clothes saturated with the odor. Air pollution might be much more difficult to perceive inside the home. On the other hand, emotions such as the heuristic affect associated with heating homes with wood-burning stoves could interfere in this perception [45,80–82].

A second mechanism that could aid in interpreting the participants' difficulty in evaluating air quality in indoor spaces is sensory habituation. Habituation is a fundamental mechanism that allows us to filter the information that reaches our brain [83]; this process is adaptive [84]. Thus, the halo effect could be understood as mere habituation to smells and other stimuli typical of pollution. Even though houses are ventilated, it has been proven that in 120 s, the brain can get used to it. In this line, seminal works by Stone et al. [85] and Sinding et al. [83] found that higher molecular weights and vapor pressures typical of contaminated houses favor greater habituation.

Third, campaigns by local information media and government institutions could increase the overall level of social concern about outdoor air pollution, but at the same time, attenuate the public's risk perception regarding indoor air quality. From studies on the social amplification and attenuation of risk, we have learned that the degree of public concern is in part influenced by how the media and government agencies portray and frame the risk [86–88]. For instance, air quality care campaigns prepared by the Ministry of the Environment include avoiding going out unnecessarily during environmental emergency periods and instead to remain indoors as one of its principal prevention measures. This message is usually addressed to sensitive groups, such as people with cardiovascular or lung diseases, children and adolescents under 12 years, older adults, and pregnant women. Thus, it is recommended that physical activity be reduced and transferred to indoor spaces, suggesting that there is greater protection in these spaces [89].

The perception of air quality indoors should be incorporated into policy agendas. Our study provides evidence that exposure to indoor particulate matter concentrations can exceed outdoor exposures if we consider the amount of time that individuals spend indoors versus outdoors. Furthermore, we show that individuals have serious problems understanding the risks they face from indoor air pollution. These findings provide the basis for providing more effective management and control of air pollution to protect southern Chilean urban communities.

There are several limitations to this study. First, to monitor human exposure to particle pollution at home, we designed, constructed, and used low-cost sensors. Our results showed high consistency with other more sensitive measurements used in previous studies conducted in Temuco. However, in the future, our sensors should be calibrated and challenged by a variety of environmental conditions in order to improve performance and reliability. In any case, the experiments performed in this study showed that the development of low-cost sensors represents a great opportunity to make interdisciplinary research in the Global South viable without the need for big budgets. Second, perception questionnaires should be filled out before, during, and after the air quality measurements in order to deepen the Hawthorne effect. Third, our study design was quasi-experimental because the groups of residents and non-residents differed in some relevant variables, such as age or education level. This limited the ability to generalize from the results obtained. Future studies will have to delve more deeply into the understanding and overall validity of the findings of this study. In this sense, we do not offer a fully developed theory of social attenuation of indoor health risks, but we do propose a fledgling framework of mechanisms that may serve to guide future research. Finally, this study was exclusively focused on participant's perceptions, but it would be interesting for other studies to use low-cost sensors to understand how the behaviors of protection and mitigation, as well as heating system use practices, affect indoor pollution levels.

5. Conclusions

This paper highlights how the relationship between objective and subjective indoor air conditions are shaped by cognitive factors. We discovered how wood smoke air pollution interacted with psychological and social processes in ways that attenuated public perceptions of indoor risks. The levels of particulate matter found in the homes in our study were similar to those outside and exceeded the limits the WHO considers healthy. Nevertheless, the participants showed a tendency to overestimate the air quality of their homes. The presence of a home halo effect could explain why this incorrect perception was more evident among the residents who, when they were in their house, tended to think the grass was always greener on their side of the fence. However, the results showed that other psychophysical and social mechanisms could be present simultaneously in the participants' ability to evaluate environmental conditions in indoor spaces.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/16/6335/s1, household initial questionnaire and visitor's questionnaire.

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Appendix A

Table A1. Sample home characteristics.

Variables	*n* (%)
Building year	
≤2000	49 (66.2)
2001–2007	11 (14.9)
>2007	14 (18.9)
Square meters	
<60	22 (31.0)
60–100	32 (45.1)
>100	17 (23.9)
Double-pane windows	
Yes, in the whole house	7 (8.9)
Yes, in some rooms	9 (11.4)
No	63 (79.7)
Main heating system	
Wood-burning stoves	52 (64.2)
Other system (pellet, gas, paraffin, electric)	29 (35.8)
Home income (CLP)	
<300 K	20 (24.7)
300–500 K	21 (25.9)
500 K–1 M	14 (17.3)
1–2.5 M	13 (16.0)
>2.5 M	5 (6.2)
Children	
Yes	57 (70.4)
No	24 (29.6)
Elderly	
Yes	67 (82.7)
No	14 (17.3)
Chronic diseases	
Yes	22 (27.2)
No	59 (72.8)
Smokers	
Yes	11 (13.6)
No	70 (86.4)

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