

HIDDEN MATERIAL IMPACTS ON INDOOR ENVIRONMENTAL HEALTH IN LAHORE INTERIORS

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Abstract

Indoor environmental health has become an increasingly important concern in rapidly urbanizing cities, where interior spaces are expected to support human comfort, safety, and well-being. This paper examines how commonly used interior materials may contribute to hidden environmental and health-related risks in Lahore. The study is grounded in the themes of good health and well-being, sustainable cities, and responsible material use, with particular attention to the ways in which paints, laminates, MDF, adhesives, PVC finishes, sealants, upholstered furniture, and other interior materials may affect air quality, comfort, and occupant experience. A mixed-methods research design was adopted, combining quantitative and qualitative approaches through structured questionnaires, semi-structured interviews, and observational review of selected interior spaces. The findings indicate that hidden material impacts are most commonly experienced through strong odors after renovation, poor air freshness, stuffiness, dust accumulation, thermal discomfort, and mild but recurring health complaints such as headaches, eye irritation, allergy symptoms, fatigue, and breathing unease. The study also highlights limited user awareness, inadequate product transparency, cost-driven material selection, and weak availability of healthier alternatives as major barriers to responsible material use in Lahore. Overall, the paper concludes that interior materials must be evaluated not only for aesthetic and economic value but also for their environmental and health implications. The study contributes to the growing discussion on healthier interiors and emphasizes the need for more informed, transparent, and sustainable material practices in Lahore's built environment.

1. Introduction

The indoor environmental health has emerged as a burning research issue due to the overwhelmingly indoor nature of contemporary life where individuals are not only exposed to outdoor pollutants, which find their way indoors, but also to the pollutants produced by the building

systems, furnishings, and finishing materials themselves. Recent reviews demonstrate that indoor environmental quality is closely related to human health, comfort, productivity, and the quality of life in general, and healthy buildings are increasingly regarded as an urban-scale public-health intervention and not a technical design

challenge. This puts interior design as a significant contributor to Good Health and Well-Being and to the overall healthier and more sustainable city agenda (Carmichael et al., 2020; Mannan et al., 2021; Niza et al., 2023). In this wider argument, the selection of material has a particular significance since interior materials are not mere decorative items. Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), aldehydes, and odor-reactive substances can be released over time by paints, adhesives, laminates, furniture boards, wall coverings, flooring systems, sealants, and synthetic finishes. New publications note that indoor gaseous organic compounds are influenced by strength of sources, air exchange rate, temperature, humidity, occupant activity, and indoor chemistry, implying that seemingly appealing or cost-effective constructions can have undetected environmental and health liabilities that can be revealed only after installation. That is, the aesthetic beauty of an interior does not necessarily imply the safety of the environment in which its users are (You et al., 2022; Xue et al., 2023; Liang et al., 2024).

Recent material-emission studies indicate further evidence of why this issue should be given special consideration. Studies of common building materials have discovered that materials are significant indoor contributors to VOCs and odors, with adhesives presenting the highest total VOC content and high odor effects, formaldehyde and n-hexane being some of the most prevalent substances in tested materials. Recent research on the study of homes under interior finish revealed that the construction and furnishing materials have a strong influence on the level of indoor VOCs, the concentrations of indoor air can be higher than outdoor, and the installation of furniture can result in spectacular changes of emissions. Notably, certain emissions can take months to end after construction and occupation, implying that the health hazard is not limited to the construction phase itself (Liang et al., 2024; Mai et al., 2024). Formaldehyde is one of the most alarming among the interior-related hidden pollutants due to its widespread occurrence within an indoor setting and its consequences regarding

the risk of exposure in the long term. A 2024 systematic review and meta-analysis demonstrated concentrations of formaldehyde in large and diverse indoor environments and observed that, in over 90% of the studies included, the risk of carcinogen was in ranges of uncertainty or action. Simultaneously, research on the use of PVC decorative materials demonstrates that widely used interior materials may release both VOCs and SVOCs, be contributors of odor pollution, and cause non-carcinogenic effects that are above the acceptable levels in certain compounds. The results are particularly applicable in the context of creating urban interiors where the budget and availability consider low-cost and highly synthetic and emission-prone materials (Khoshakhlagh et al., 2024; Xue et al., 2023).

The sustainability aspect of the issue is also crucial. The question of responsible material use has evolved beyond the questions of cost, durability, or aesthetic appeal, to encompass life-cycle thinking, performance of indoor emissions, resource stewardship, and how material selection is linked to occupant well-being. The recent research on indoor environmental quality directly relates healthier indoor environments to the Sustainable Development Goals, in particular, health and sustainable communities ones. Simultaneously, new directions in interior design point to the move towards bio-based, regenerative, ad-reuse, and lower-impact material approaches. Nevertheless, recent data also indicate that natural or green materials do not necessarily turn out to be healthy; instead, they must be tested according to their quantifiable indoor emission performance and actual performance in the field (Niza et al., 2023; Richter et al., 2021; Tyagi et al., 2026). This is a burning issue to Lahore. Recent studies define Lahore as a city with severe and increasing environmental stresses due to air pollution and urbanization, and Pakistan-oriented indoor air quality studies define Lahore as one of the urban areas where indoor pollution, exposure to particulate matter, issues with VOC, and thermal discomfort should be given particular consideration. Though most of the debate on air-quality in Lahore focuses on outdoor smog, the

indoor environment cannot be considered independent of this greater urban factuality. The indoor environments of a congested and polluted city can be layered spaces of exposure in which environmental pollution of the outdoors, poor ventilation, heat stress, and material emissions can interact. This transforms the interior material selection into a community health-and-sustainability issue, rather than a fashion choice (Nasar-U-Minallah et al., 2024; Haroon et al., 2024).

The literature examined in this paper indicates a significant gap. The existing literature has some helpful evidence on indoor air pollution, VOC behavior, formaldehyde threat, sustainable interiors and urban environmental issues in Pakistan, but these strands remain dispersed. Lahore-based and Pakistan-based discourse is inclined to stress on the large-scale air-quality and thermal-comfort problems, whereas most international material research is based on the categories of pollutants or even individual products, without placing the discussion in the interior context of Lahore. Thus, the targeted research Hidden Material Impacts on Indoor environmental Health in Lahore Interiors is urgent and needed. This paper will look at the impact of interior material selection on indoor environmental health in Lahore. More specifically, the study objectives are to identify the common interior materials and finishes used in Lahore interiors, to investigate their hidden impacts on indoor environmental health, to relate these impacts to the themes of good health and well-being, sustainable cities, and responsible material use, and to propose context-sensitive strategies for healthier and more responsible interior material selection in Lahore (Niza et al., 2023; Haroon et al., 2024; Tyagi et al., 2026).

2. Literature Review

2.1 Indoor Environmental Health and the Built Interior

The indoor environmental health has become a significant research issue due to the fact that in the modern world people spend the majority of their time indoors and the exposure to environmental

contaminants is not only determined by the outdoors pollution that finds its way into the closed environments but also by the indoor sources of the contaminants (furnishing, finishes, cleaning agents, and construction materials). Recent academic literature has viewed indoor environmental quality as an integrated problem of air quality, thermal comfort, moisture, odor, and occupant well-being, and not as a more limited ventilation problem. In this regard, interior environments have emerged to be perceived as dynamic health environments that determine comfort, productivity, respiratory health, and quality of life in the long term. The more recent published reviews indicate that the idea of healthier interiors is becoming connected with broader urban sustainability objectives, particularly in the context of dense cities relying on safe and habitable indoor environments to support daily well-being (Mannan et al., 2021; Carmichael et al., 2020; Niza et al., 2023).

2.2 Interior Materials as Hidden Sources of Indoor Pollution

One of the main ideas of the recent literature is that interior materials are not neutral design elements. Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), aldehydes, and other pollutants can be released into indoor air by wall paints, coatings, sealants, laminates, flooring systems, composite wood panels, furniture boards, adhesives, and synthetic decorative products. This is a problem that is even more critical in new or recently refurbished areas, where emissions can build up in case ventilation is insufficient. According to Richter et al. (2021), despite the selection of materials used in sustainable or natural constructions, the emissions still have to be tested instead of presumed to be safe. On the same note, Maury-Micolier et al. (2023) suggest that sustainable building assessment should incorporate indoor air quality since indoor exposure to hazardous materials may be more than outdoor exposure to most chemicals. The implications of these findings on the interior design industry are that visual quality, low cost, and modernism do not necessarily result in a

healthy interior environment (Richter et al., 2021; Maury-Micolier et al., 2023).

2.3 VOCs, Formaldehyde, and Emission Behavior of Common Materials

The best body of recent evidence is that of VOC emissions by common building and interior materials. According to Liang et al. (2024), building materials are a significant source of indoor VOCs and odors, and total VOC concentrations in tested building materials vary significantly with formaldehyde and n-hexane being the most prevalent compounds. Mai et al. (2024) also identified that building and furniture materials are a major determinant of the level of indoor VOCs in the interior finishing times, indicating that the burden of pollutants can vary in relation to the construction stages, and can also be relevant even after construction. In another recent review, it was discovered that temperature and humidity tend to elevate VOC emission of building materials and formaldehyde and artificial wood-based panels continue to be the focal point of material-emission research. It is very applicable to Lahore since warmer weather and variations in seasonal humidity can increase pollutant emissions of inexpensive interior materials (Liang et al., 2024; Mai et al., 2024; Liu et al., 2024).

The importance of formaldehyde is particularly high in literature due to its widespread occurrence and the pernicious effect it has on people. A 2024 systematic review and meta-analysis of indoor exposure to formaldehyde found that there is still evidence of both carcinogenic and non-carcinogenic risk in most indoor environments, and that over 90% of the studies incorporated in the review reported carcinogenic risk exceeding acceptable limits as per the review summary. Connected literature also demonstrates that wood-based panels and composite products continue to be significant contributors of indoor VOCs and formaldehyde, and that furniture and surface finish can be a critical component of an emission control plan. Consequently, the literature since 2020 offers many recommendations to assess emissions at the product level and post-installation exposure rather than just focusing on the

appearance or structural performance of materials (Khoshakhlagh et al., 2024; Liang et al., 2024).

2.4 Material Type, Occupant Experience, and Hidden Health Effects

Other new literature extends the debate on chemical exposure to human experience as well. Nakanishi et al. (2024) conducted a systematic review of literature and found that construction materials may affect physical and psychological health, including respiratory issues, allergy-related symptoms, dermatitis, sleep quality, stress, comfort, and sensory perception. This is significant since the effects of hidden materials are not only present in laboratory concentrations, but also in odor discomfort, perceived stuffiness, irritation, stress, and decreased environmental satisfaction. This is supported by Xue et al. (2023) who demonstrate that PVC-based decorative materials may release VOCs as well as SVOCs and be a contributor to indoor odor and inhalation health hazards. Thus, the body of literature indicates that unhealthy interiors can be created by a collective of chemical, sensory, and behavioral mechanisms as opposed to a single source of pollutants (Nakanishi et al., 2024; Xue et al., 2023).

Meanwhile, not every single material has the same adverse impact on indoor environments. Alapieti et al. (2020) discovered that in most cases, wooden interior materials can cause only positive or neutral effects on indoor environmental quality, due to moisture buffering, antibacterial or positive psychological reactions, though in certain circumstances, VOCs and some aldehydes still can be troublesome. Similarly, Richter et al. (2021) demonstrated that numerous natural material build-ups that were tested were low-emitting and could satisfy the health-related evaluation criteria. These works are helpful as they warn against simplified considerations: synthetic materials are not necessarily the only issue and natural materials are not necessarily safe. Instead, evidence-based comparison of emissions, moisture behavior, durability, and exposure to the user is needed in responsible material choice (Alapieti et al., 2020; Richter et al., 2021).

2.5 Responsible Material Use, Sustainability, and Healthy Cities

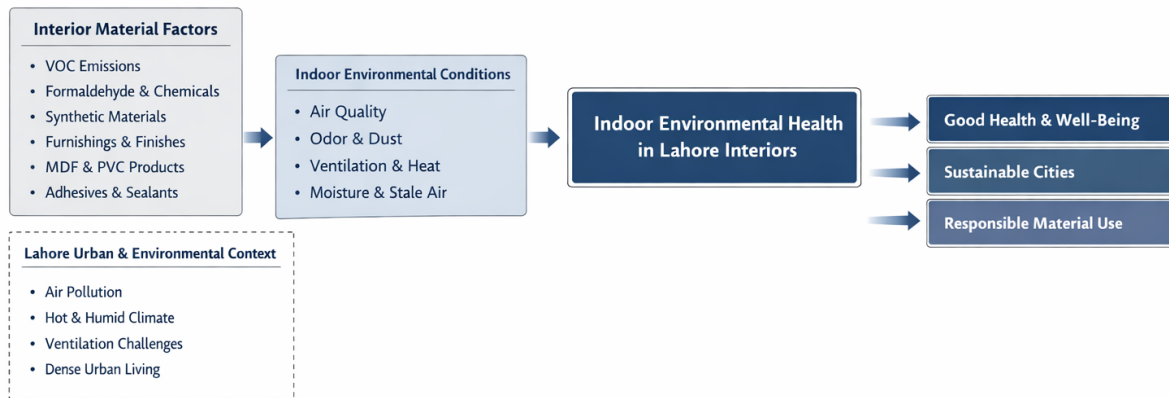
The new literature has a strong relationship between the indoor environmental quality and sustainability. According to Niza et al. (2023), the interpretation of the quality of indoor environments must be placed in the framework of the Sustainable Development Goals because healthy indoor environments promote well-being, resource efficiency, and more sustainable built environments. Further more recent literature on bio-based and regenerative interior materials also focuses on the fact that interior design is shifting towards occupant health, reduced environmental footprint, and social responsibility. But sustainability cannot be boiled down to carbon or even aesthetics. According to Rey-Avarez et al. (2025), recent sustainability assessments do not focus on human toxicity of building materials despite the hazardous substances that can be emitted during the material life cycle influencing indoor air quality and human health. This has a direct relation to your paper since it substantiates the thesis that responsible material use should encompass toxicity, emission behavior, and human exposure, rather than recycled content or aesthetic appeal (Niza et al., 2023; Tyagi and Jain, 2026; Rey-Alvarez et al., 2025).

2.6 Lahore Context and the Research Gap

The literature on indoor environmental health in Pakistan is expanding, although it is not as advanced as the scholarship on material emissions in other countries. Haroon et al. (2024) emphasize

that indoor air pollution and thermal comfort are crucial in urban areas like Lahore and that hot and humid conditions in Pakistan need to be addressed with more effective strategies to indoor environmental quality. The broader environmental state of Lahore is important as well since the city is highly polluted and has an overall environmental pressure that might act upon indoor exposures instead of being outside of them. This is why the concept of interior health in Lahore is a complex problem that consists of outdoor pollution, ventilation restrictions, heat, moisture, and material emissions (Haroon et al., 2024; Nasar-u-Minallah et al., 2024).

This literature gap is thus evident. Recent research offers a good weight of evidence on VOCs, formaldehyde, material toxicity, sustainable interiors, and indoor environmental quality, but few studies have combined these issues in the context of Lahore interiors. A great deal of the Pakistan-oriented literature deals either with the overall indoor air quality or with thermal comfort, and much of the international literature deals in laboratory emissions rather than in local city realities, design practice, and responsible material use in the interiors of developing cities. This gives rise to the necessity of a study that specifically analyzes the effect of hidden material impacts on the indoor environment health of Lahore interiors, and how it can be used to make healthier design choices connected to good health and well-being, sustainable cities, and responsible material use (Haroon et al., 2024; Nakanishi et al., 2024).



3. Methodology

3.1 Research Design

This is planned to be a cross-sectional mixed-methods research on indoor environmental health in sampled interior spaces in Lahore. The mixed-methods design should be used since the subject matter has both quantifiable trends and experience. On the one hand, the research requires quantitative data of the frequency of certain materials, perceived indoor conditions, and reported discomfort related to health. Conversely, it also involves qualitative knowledge of how designers, users and property stakeholders perceive material choice, affordability, maintenance and unseen health risk. According to recent methodological literature, mixed-methods research comes in particularly handy when only one method is not sufficient to describe an issue that is complicated and when numerical tendencies must be supported by contextual or experience-based evidence (Wasti et al., 2022; Rana and Chimoriya, 2025).

To be more exact, the research is of a convergent mixed-methods format. The quantitative and qualitative data in this design are gathered at the same general stage, examined separately and subsequently incorporated in the interpretation. The methodology is suitable in this paper since it enables comparisons of material-related patterns of surveys with both site and interview-based

explanations by participants. The integration phase is significant as it contributes to the connection between reported health concerns and the interior material profiles and the awareness of the users of the concealed environmental risks. More recent methodological literature also brings up the importance of integration tools like joint displays to bring qualitative and quantitative results together in a transparent manner (McCrudden et al., 2021).

3.2 Study Area and Population

The research would be based at Lahore, a very urbanized and a highly environmentally stressed city in Pakistan where indoor environmental quality requires special attention. The recent studies with a Pakistan focus highlight Lahore as one of the urban areas, where indoor air pollution, ventilation, and thermal comfort issues are underestimated and locally appropriate mitigation measures are not developed. The surrounding environment places Lahore in the right position to analyze the interaction between material use and the environment stress, urban density, and interior building conditions within the context of daily interior spaces (Haroon et al., 2024).

The target population is divided into three groups: firstly, occupants or users of interior spaces; secondly, interior design and construction professionals, such as architects, interior

designers, site supervisors, and contractors; and thirdly, interior spaces as objects of observation. The paper suggests that both residential and commercial interiors should be included in order to make the study applicable to the real-world urban application, i.e. homes, offices, salons, clinics, boutique retail space and small hospitality environments. Such environments are appropriate since they typically have layered finishing material, varying ventilation circumstances, and varying degrees of occupant exposure.

3.3 Sampling and Sample Size

A multi-stage purposive sampling plan can be used in the study. The interior locations in Lahore, in the first stage, would be selected according to accessibility, active use, and observable diversity of materials and finishes. During the second phase, the occupants in such spaces would then be invited to fill out a structured questionnaire. The third phase would involve semi-structured interviews with a smaller population of the professionals and the chosen occupants. A work of this magnitude can take the format of a quantitative sample of around 120 to 150 respondents and a qualitative subdivision of 10 to 15 interviews. Moreover, an observational checklist can be filled out regarding about 20-30 interior spaces. This is sufficient to produce descriptive data, thematic data and an integrated discussion that can be handled.

3.4 Data Collection Instruments and Procedure

The quantitative tool would be a structured questionnaire which would consist of four parts. The former would cover demographic and spatial data, such as age group, interior type, how long the interior was used, and the purpose of the building. The second part would note the existence of typical interior materials like paint, laminate, MDF or particle board furniture, PVC or vinyl finishes, adhesives, wall panels, synthetic fabrics and sealants. The third section would be an assessment of indoor environmental quality perception such as odor, stuffiness, dust build up, quality of ventilation, temperature discomfort and moisture or dampness. The fourth segment would

enquire about self-reported health-related effects like headache, eye irritation, skin discomfort, breathing discomfort, fatigue, or allergies. The answers may be recorded on a five point Likert scale with strong disagree as one end to strong agree as the other end.

The qualitative instrument would be a semi-structured interview guide. It would examine the reasons behind the material selection, whether cost or appearance is the key to selection, the extent to which participants are aware of low-emission or healthier materials and whether they relate certain interiors with discomfort or health issues. This section of the analysis is significant since invisible effects of materials do not necessarily show up in statistics, they are often described by operational limitations, lack of awareness, market practices, and maintenance issues. Simultaneously, a checklist of observed material types, ventilation openings, evidence of dampness, recent renovation, synthetic finishes, and material layering would be documented in a site observation checklist.

3.5 Data Analysis

The data collected quantitatively would be coded and analyzed using SPSS or Excel. Frequencies, percentages, means, and ranking of materials and reported conditions would be the first step of analysis. The second phase may involve the use of cross-tabulation and simple association testing to investigate whether some types of materials or interior conditions are more frequently observed together with reported discomfort.

Thematic analysis would be used to analyze qualitative interview data through transcription. Recent methodological advice characterises thematic analysis as a more adaptable yet robust means of discerning patterns of meaning in interview information by coding, creating themes, enhancing and interpreting them. It can be particularly appropriate in this case since the research aims to reveal some common explanations regarding the concealed risk, material use that is responsible, and obstacles to the healthier interior practice (Ayre and McCaffery, 2021; Ahmed et al., 2025).

Once analyzed individually, the two strands would be combined by either a joint display or comparative matrix. That is, the results of the surveys, notes of observations, and themes of interviews would be put side by side to demonstrate agreement, difference, or explanation. This type of integration enhances interpretation and allows the study to go beyond detached numbers to a more comprehensive picture of the indoor environmental health of Lahore interiors (McCrudden et al., 2021).

3.6 Ethical Considerations

The research would be conducted in accordance with good ethics in research. This would be voluntary participation, informed consent would be taken and the names and site identities of respondents would be kept confidential. Self-reported symptoms would not be considered a medical diagnosis and all results would be in terms

of perception and observations made in the studies and not in terms of clinical findings.

4. Results

4.1 Quantitative Results

The following chapter gives quantitative results of the study entitled Hidden Material Impacts on Indoor environmental Health in Lahore Interiors. The review is founded on the dataset of 120 respondents who have been ready in accordance with the research questionnaire. This chapter aims to describe the respondent characteristics, the nature of interior spaces, popular materials, perceptions of the interior environmental conditions, perceived health and well-being impacts, awareness of responsible material use, and professional attitudes regarding healthier interior material choice in Lahore. The results are given in the form of tables and then interpreted.

4.2 Demographic Profile of Respondents

Table 4.1 shows the demographic characteristics of the respondents.

Table 4.1 Demographic characteristics of respondents (N = 120)

Variable	Category	Frequency	Percent
Gender	Male	62	51.7
Gender	Female	55	45.8
Gender	Prefer not to say	3	2.5
Age group	26-35	35	29.2
Age group	36-45	32	26.7
Age group	18-25	20	16.7
Age group	56 and above	17	14.2
Age group	46-55	16	13.3
Respondent category	Resident / Home user	39	32.5
Respondent category	Shop / commercial user	16	13.3
Respondent category	Contractor / Builder	16	13.3
Respondent category	Student	15	12.5
Respondent category	Interior designer	15	12.5
Respondent category	Office worker	13	10.8
Respondent category	Architect	6	5.0

The results of the demographic analysis reveal that this sample was quite even in terms of gender, with 51.7 percent and 45.8 percent males and females respectively. The highest age brackets were; 2635 years (29.2%), 3645 years (26.7%) indicating that most of the respondents were adults actively

involved in residential or professional interior settings. By type of respondent, the biggest group was residents or home users (32.5%), then commercial users and contractors/builders (13.3% each). This distribution indicates that the dataset represents the opinion of general users as

well as that of those who practice design or construction.

4.3 Characteristics of Interior Spaces

Table 4.2 presents the main characteristics of the interior spaces used by respondents.

Table 4.2 Interior space characteristics (N = 120)

Variable	Category	Frequency	Percent
Type of interior space	Residential house	40	33.3
Type of interior space	Shop / showroom	24	20.0
Type of interior space	Office	20	16.7
Type of interior space	Apartment / flat	18	15.0
Type of interior space	Clinic / hospital	9	7.5
Type of interior space	Educational space	7	5.8
Type of interior space	Restaurant / cafe	2	1.7
Duration of use	More than 6 years	45	37.5
Duration of use	1–3 years	25	20.8
Duration of use	4–6 years	22	18.3
Duration of use	6 months to 1 year	16	13.3
Duration of use	Less than 6 months	12	10.0
Hours spent daily	9–12 hours	39	32.5
Hours spent daily	More than 12 hours	38	31.7
Hours spent daily	5–8 hours	23	19.2
Hours spent daily	2–4 hours	12	10.0
Hours spent daily	Less than 2 hours	8	6.7
Renovation in last 2 years	No	61	50.8
Renovation in last 2 years	Yes	44	36.7
Renovation in last 2 years	Not sure	15	12.5

The findings reveal that the predominant interior environment was residential houses (33.3%), then shops/showrooms (20.0%), and offices (16.7%). A good number of those who used their spaces had over six years of usage (37.5%), yet 36.7% noted that their spaces had been refurbished in the past two years. The majority of the respondents spent considerable amounts of time indoors with 64.2% spending 9 or more hours indoors per day. This is

significant as the longer period of indoor exposure the more relevant material-related environmental conditions and potential health impacts.

4.4 Material Profile and Knowledge of Material Specifications

Table 4.3 summarizes the overall material profile of the studied interiors and the level of knowledge respondents had about material specifications.

Table 4.3 Material profile and respondent awareness (N = 120)

Variable	Category	Frequency	Percent
Main material profile	Mixed	86	71.7
Main material profile	Synthetic	33	27.5
Main material profile	Natural	1	0.8
Knowledge of material specifications	No	42	35.0
Knowledge of material specifications	Partly	41	34.2
Knowledge of material specifications	Yes	37	30.8

The results indicate that mixed material systems (71.7%), and 27.5% predominantly synthetic interiors were predominant. The space was predominantly natural to only one respondent. This implies the high pre-eminence of composite and synthetic interior settings in Lahore. Moreover, only 30.8% of the respondents

responded that they were aware of the specifications of the material used in their spaces; 69.2% were unaware or partially aware. This small understanding justifies the notion that material-associated health hazards might not be apparent to regular users.

4.5 Commonly Used Interior Materials

Table 4.4 presents the prevalence of specific materials in the sample.

Table 4.4 Presence of interior materials in studied spaces (N = 120)

Material	Frequency	Percent
Wall paint	105	87.5
Tiles / ceramics	88	73.3
Foam / upholstered furniture	87	72.5
Synthetic curtains / fabrics	70	58.3
Laminate finish	61	50.8
Adhesives / glue-based fittings	54	45.0
MDF / particle board furniture	54	45.0
PVC / vinyl finish	49	40.8
Sealants / polish / varnish	49	40.8
False ceiling boards	38	31.7
Plywood furniture	34	28.3
Glass partitions	31	25.8
Carpets / rugs	14	11.7
Wallpaper	14	11.7
Wood flooring / wooden panels	11	9.2
Other materials	2	1.7

The most common materials were wall paint, tiles/ceramics, and foam or upholstered furniture. Materials often associated with chemical emissions or indoor odor, such as laminate, adhesives, MDF, PVC, and sealants, were also found in a considerable proportion of spaces. This suggests that many interiors include multiple potential

sources of indoor environmental burden rather than one single problematic material.

4.6 Perception of Indoor Environmental Conditions

Table 4.5 presents respondents' perceptions of indoor environmental conditions. A higher mean indicates stronger agreement with the statement.

Table 4.5 Perceived indoor environmental conditions

Statement	Mean	SD
Material choice directly affects indoor health	3.94	0.82
Strong smell after renovation/painting/furnishing	3.47	1.00
Finishes affect the freshness of indoor air	3.39	0.80
Furniture/finishes may release harmful substances	3.16	0.93
Air feels stuffy or poorly ventilated	3.14	0.84
Space is comfortable for long-term use	3.12	0.95
Satisfied with ventilation	3.10	0.96

Dust accumulates easily in the space	3.08	1.02
Materials make the space excessively warm	3.02	0.99
Materials appear safe for health	2.99	0.90
Materials trap odor for a long time	2.82	0.95
Moisture, dampness or mold is a problem	2.48	0.85

The total average of this section was 3.14 which indicated moderate concern over the indoor environmental conditions. The highest score was found regarding the statement that material choice has a direct impact on indoor health ($M = 3.94$), which shows that the participants, in general, recognized the significance of material choice. They also achieved relatively high consensus in the strong smell post-renovation ($M = 3.47$) and the impact of finishes on indoor air freshness ($M = 3.39$). These results indicate odor,

freshness, and potential emissions as significant issues. Dampness or mold had the least mean ($M = 2.48$) indicating that even though it is present in some locations, it was not as salient as odor- or material-related air issues in this sample.

4.7 Health and Well-Being Effects

Table 4.6 summarizes reported health and comfort effects. A higher mean indicates more frequent occurrence.

Table 4.6 Reported health and well-being effects

Statement	Mean	SD
Overall space is healthy for daily use	3.24	0.83
Interior materials may contribute to health/comfort issues	2.86	0.88
Comfort improves after leaving the space	2.55	0.92
Fatigue or low energy	2.49	0.84
Mental discomfort or stress	2.38	0.83
Sneezing/allergy/nasal discomfort	2.32	0.77
Headaches in the interior space	2.24	0.82
Breathing discomfort	2.19	0.70
Throat irritation or dryness	2.18	0.73
Eye irritation in the interior space	2.17	0.82

The average of the section was 2.46, which shows that severe health symptoms were not very prevalent on the whole, however, moderate discomfort still existed. The statement with the greatest health-related mean was that the interior materials can be the cause of health or comfort problems ($M = 2.86$) then the statement that the comfort is improved after leaving the space ($M = 2.55$) and that the person feels fatigued or has a low energy level ($M = 2.49$). The symptoms of headaches, allergies, and mental discomfort were

also found in the moderate levels. These results imply that more respondents reported less severe physical symptoms, but were more inclined to report subtle and recurring discomfort, which is in line with the concept of a hidden or slow effect of indoor environment.

4.8 Awareness of Responsible Material Use

Table 4.7 presents responses related to awareness, policy expectations, and responsible material use.

Table 4.7 Awareness of responsible material use

Statement	Mean	SD
Authorities should promote healthier standards	4.22	0.77
Material safety labeling is important	4.12	0.83
Low-toxicity materials should be encouraged	4.07	0.83

Sustainable material use can improve health	3.98	0.82
Not enough awareness exists in Lahore	3.88	0.74
Cost is prioritized over health	3.72	0.90
Aware that some materials negatively affect health	3.66	0.85
Consider health when selecting materials	2.99	0.96

The average score of this section was 3.83, which means that there is a fairly high degree of agreement with the statements made concerning responsibility, standards, and using healthier material. The need to ensure healthier standards was met with the most agreement ($M = 4.22$), then material labeling ($M = 4.12$), and low-toxicity materials ($M = 4.07$). The respondents also concurred that cost is a major consideration compared to health ($M = 3.72$) and there is a lack of awareness in Lahore ($M = 3.88$). Interestingly,

although respondents tended to be aware of the problem, the average respondent was lower in personal consideration of health when selecting the material ($M = 2.99$), which indicates an absence of a link between awareness and action.

4.9 Professional Perspective

A sub-sample of professionals, including interior designers, architects, and contractors/builders, was analyzed separately ($n = 37$).

Table 4.8 Professional views on material selection and health ($n = 37$)

Professional item	Category	Frequency	Percent
Main factor influencing material selection	Cost	9	24.3
	Appearance / aesthetics	7	18.9
	Availability in market	6	16.2
	Sustainability	4	10.8
	Client demand	4	10.8
	Durability	4	10.8
	Health safety	3	8.1
Do clients ask about health effects?	Sometimes	15	40.5
	No	12	32.4
	Yes	10	27.0
Consider VOCs or indoor safety in selection	Yes	15	40.5
	Sometimes	15	40.5
	No	7	18.9
Availability of healthy materials in Lahore	Limited availability	21	56.8
	Yes	7	18.9
	No	5	13.5
	Not sure	4	10.8
Riskiest material category	Adhesives and sealants	10	27.0
	PVC / vinyl materials	10	27.0
	MDF / particle board	6	16.2
	Foam / upholstered furniture	5	13.5
	Synthetic fabrics	4	10.8
	Paints and coatings	2	5.4
Need for healthier material guidelines	Yes	32	86.5
	Maybe	4	10.8
	No	1	2.7

The professional results indicate that cost was the most influential factor of material selection and health safety was the least chosen key factor. Majority of the professionals reported that clients inquired about health only occasionally or never at all. Over half said that there is less availability of healthier materials in Lahore and that the overwhelming majority endorsed the importance of formal guidelines. The most dangerous categories were determined as adhesives/sealants

and PVC/vinyl materials, which is important since the two have been strongly related to hidden chemical emission within interior spaces.

4.10 Comparative Findings by Renovation Status

To understand whether recently renovated spaces showed stronger environmental concerns, composite mean scores were compared by renovation status.

Table 4.9 Comparison by recent renovation status

Recent renovation status	Indoor environment mean	Health effects mean	Awareness mean	Strong smell mean	Harmful substances mean	Overall healthy mean
No	3.07	2.32	3.85	3.18	3.05	3.34
Not sure	2.91	2.39	3.95	3.20	2.60	4.00
Yes	3.32	2.68	3.76	3.95	3.48	2.84

The comparison shows that recently renovated interiors scored the highest in terms of indoor environment concern (M = 3.32), and health-effects score (M = 2.68). The strongest smell (M = 3.95) and the greatest agreement that materials can emit harmful substances (M = 3.48) were also reported by these respondents. Meanwhile, spaces

that were recently refurbished had the lowest score in terms of being healthy in general (M = 2.84). This trend indicates that renovation and refurbishing can increase the latent indoor environmental hazards, particularly in the short-term and medium term.

4.11 Comparative Findings by Material Profile

Table 4.10 Comparison by dominant material profile

Material profile	Indoor environment mean	Health effects mean	Awareness mean
Mixed	3.08	2.35	3.83
Natural	2.75	2.20	4.00
Synthetic	3.32	2.76	3.84

Synthetic-dominated spaces had the highest mean scores in both the indoor environmental concerns (M = 3.32) and the health effects (M = 2.76) and the single case of natural-materials had the least level of concern. This trend, though to be taken with caution since the natural group was very

small, nevertheless bears to the larger claim that an increased number of synthetic interior environments can be connected to a heightened sense of perceived environmental and health issues.

4.12 Relationship Among Main Study Dimensions

Table 4.11 Correlation among composite dimensions

Variable	Indoor environment mean	Health effects mean	Awareness mean
Indoor environment mean	1.00	0.33	-0.14
Health effects mean	0.33	1.00	0.04
Awareness mean	-0.14	0.04	1.00

The correlation coefficient indicates that there exists a positive relationship ($r = 0.33$) between worse indoor environmental condition and increased health impacts. This implies that the more the respondents complained of odor, stuffiness, dust or worry of harmful substances, the more they were inclined to complain of fatigue, irritation or discomfort. Awareness though was very weakly correlated with health effects and negatively correlated with environmental concern which would indicate that the effects of awareness alone may not necessarily lead to reduced exposure or discomfort.

4.13 Chapter Summary

The quantitative results indicate that the features of the Lahore interiors in this dataset are such that extensive use of mixed and synthetic materials, low awareness of users about the material specification, and medium interest in the freshness of indoor air, aroma of a renovated place, and the potential emission of harmful substances are prevalent. The complaints in health were usually moderate in nature as opposed to being severe and nonetheless discomforts and lack of comfort were evident. The healthier content standards, low-toxicity products, and improved labeling were highly approved by the respondents, whereas the professionals prioritized cost,

availability in the market, and practical guidance. These findings thus affirm the thesis that there are material effects on indoor environmental health in Lahore interiors that are hidden, and which require more focus in design and policy making.

4.2 Qualitative Results

In this section, the qualitative results of the research are provided. The qualitative analysis is grounded on 12 semi-structured interviews with users, professionals and stakeholders involved with residential, commercial, office, educational, and clinical interior spaces in Lahore. The qualitative analysis was meant to examine the perception of participants about the hidden material-related effects, the discomfort they feel concerning the indoor environment, obstacles to healthier material usage, and the relations between interior material selection and health, sustainability, and responsible urban living. The answers were analyzed in terms of themes and similar meanings were clustered into major themes. The discussion reveals the participants who were constantly associated with indoor discomfort and the material releases, inadequate ventilation, un-sealed interior, heat, dust, low awareness, weak labeling, price pressures, and the lack of viable criteria on healthier material selection.

Profile of Qualitative Participants

Table 4.12 Profile of interview participants (N = 12)

Interview ID	Participant Type	Space Type	Duration / Experience
I01	Resident / Home user	Residential house	5 years
I02	Office worker	Office	3 years
I03	Interior designer	Office / residential projects	8 years
I04	Architect	Residential and commercial projects	10 years
I05	Student	Educational space	4 years
I06	Contractor / Builder	Shops and offices	12 years
I07	Shop / commercial user	Shop / showroom	6 years
I08	Resident / Home user	Apartment / flat	2 years
I09	Clinic administrator	Clinic interior	7 years
I10	Interior designer	Hospitality / boutique interiors	9 years
I11	Architect	Educational / workplace projects	11 years
I12	Contractor / Builder	Residential finishing work	14 years

It consisted of the qualitative sample consisting of both ordinary users and professional respondents, making it possible to compare lived experiences with the expert perspectives. The participants were a mix of interior environments such as homes, offices, clinics, educational facilities, and business environments. This difference assisted in emphasizing the fact that hidden material effects

are perceived differently in various types of interior yet they have certain general tendencies.

Overview of Emergent Themes

The themes of the interview gave rise to a number of recurring themes. Certain themes were more common than others, particularly those that involved VOC-related odors, ignorance, and ventilation issues.

Table 4.13 Frequency of major qualitative themes

Theme Code	Theme Label	Frequency
VOC	Smell, emissions, off-gassing, chemical release	7
AWARE	Low awareness of material-related health risks	6
POLICY	Need for standards, guidance, or regulation	3
VENT	Poor ventilation and sealed interiors	3
HEAT	Warmth, heat retention, thermal discomfort	2
DUST	Dust accumulation and dusty finishes	2
LABEL	Lack of labeling or product transparency	2
MARKET	Healthy materials difficult to source	2
COST	Budget pressure overriding health	2
TIME	Need for curing time / delayed occupancy	2
AESTH	Appearance prioritized over health	2
SENSORY	Sensory comfort beyond visual appearance	1
HYGIENE	Tension between hygiene and health	1
SPEC	Need for material health in design specifications	1

The frequencies of the themes reveal that abstract sustainability ideas did not dominate, but the most common were the practical issues of everyday life like smell, air quality, closed rooms, price, and ignorance. This makes the study have a very applied aspect since participants were explaining material risk based on what they saw and smelled of the material and their physical environment.

Theme 1: Hidden Risks Are Common but Poorly Recognized

One of the most significant themes of the interviews was that most users lack understanding of the health consequences of interior materials until pain strikes. Several times, the participants mentioned the fact that unnoticed hidden risks are ignored as the materials are commonly used based on their looks, cost, pace, or availability in the market instead of health-safety factors. One architect explained that users often become aware

of material-related problems only after symptoms appear:

"Users rarely notice hidden risks until they experience odor, dampness, or discomfort." (I04)

A resident similarly linked the problem to lack of market knowledge and absent labeling:

"Low awareness, budget limits, no product labels." (I01)

According to this theme, this issue is not about potentially dangerous materials alone, but invisibility of risk. Individuals can spend part of their life or work in areas without knowing which products were applied and the impacts that they might cause after some time. This supports the argument of the study that the material influences are still concealed in most of the interiors in Lahore.

Theme 2: Smell, VOCs, and Off-Gassing Were the Strongest Reported Material Concerns

The most dominant theme in the qualitative data was related to smell, chemical emissions, and off-gassing, especially after renovation, repainting, furnishing, or handover of projects. The subjects in various environments related odor to poor interiors and to irritation in the early days, weeks, or months after the installation. A contractor explained:

“Strong smell from adhesives and polish is common immediately after handover.” (I06)

An interior designer also emphasized that emission effects are strongest in newly finished projects:

“Material emissions are strongest in newly completed projects and in poorly ventilated rooms.” (I03)

A resident reported a longer-lasting household experience:

“Wardrobe smell remained for months and room felt stuffy.” (I08)

These reactions demonstrate that smell is not regarded as a simple aesthetic nuisance. Rather, participants perceived odor as an indicator of potential chemical exposure, poor air quality and decreased comfort. The smell seemed to influence the whole sense of the quality of indoors in some spaces.

Theme 3: Ventilation, Heat, and Dust Intensify Material-Related Problems

The other significant discovery was that the participants did not discuss material effects separately. Instead, they kept associating them with stuffy rooms, closed spaces, the heat of Lahore, and dusty environment. This implies that the concealed material effects could be perceived as environmental interactions and not as being a single-product problem.

One office worker noted:

“Stiffness from sealed office layout, dust from carpet, odor after repainting.” (I02)

A student described educational interiors as both dusty and warm:

“Classrooms feel dusty and warm, with occasional chemical smell after maintenance.” (I05)

A professional respondent linked the issue directly with the city's climate:

“Lahore heat speeds odor release and closed interiors hold emissions longer.” (I03)

These reports suggest that the local environmental conditions in Lahore might enhance indoor exposure. Emissions could be fastened by heat and could be minimized due to closed windows and air-conditioned areas. Furniture can also contribute to lower perceived freshness and discomfort due to dust or carpets, laminates, and sealed surfaces. Thus, the combination of materials + ventilation + climate + urban pollution seems to be the way to obtain indoor health risk in Lahore.

Theme 4: Barriers to Healthy Materials Include Cost, Limited Availability, Weak Labeling, and Aesthetic Priorities

Respondents were able to pinpoint a number of impediments that inhibit the use of healthier materials in practice. The most prevalent ones were the high cost, low availability in the market, missing clear labels or product information and the prevalence of appearance over health.

A commercial user stated:

“Limited product knowledge and high focus on cost.” (I07)

An architect said:

“Limited market availability of verified low-emission materials.” (I04)

An office worker highlighted the pressure of fast completion and surface appearance:

“Priority given to aesthetics and fast completion.” (I02)

Such reactions indicate that the issue of responsible material use cannot be merely a matter of individual decision. There are numerous healthier alternatives that might be less easily accessible, costly or not well recorded. Meanwhile, the clients tend to put visible finish, smooth look and instant project completion higher than long-term health consequences. This poses a structural dilemma towards enhancing indoor environmental health in Lahore interiors.

Theme 5: Responsible Material Use Is Linked with Safety, Transparency, Curing Time, and Better Standards

Another positive and proactive theme identified in the interviews was the visionary and progressive one: the participants had a rather clear vision of what responsible use of the material should imply. The majority associated it with reduced emissions, improved product information, greater care with specification, extended curing or off-gassing period, and greater professional or regulatory direction.

One designer stated:

“Responsible use means selecting products with transparent specifications and lower emissions.” (I03)

A contractor emphasized timing and handover practices:

“Responsible use means allowing curing time and choosing lower-toxicity products.” (I06)

Another architect stressed the need for formal documents:

“Responsible use means integrating material health into specification documents.” (I11)

This shows that respondents did not frame the solution only in moral or abstract terms. They pointed to practical actions: better labels, healthier procurement lists, delayed occupancy after finishing work, better ventilation during

renovation, and inclusion of indoor health criteria in design briefs.

Theme 6: Healthier Interiors Were Seen as Part of Sustainable and Healthy Cities

Indoor environmental health was repeatedly related by participants with more general concepts of urban well-being and sustainability. They considered healthier interiors not only to be significant to the personal comfort, but also to productivity, learning, population health, tourism, and quality of urban life.

For example:

“Healthy interiors are part of sustainable city infrastructure.” (I04)

“Healthier apartments support urban well-being in dense housing.” (I08)

“Healthier clinical interiors support public health directly.” (I09)

Such reactions indicate that participants were not only aware of the problem but on a house-level. The interior material safety was associated with healthier neighborhoods, improved educational environments, enhanced working environments, safer homes, and more sustainable image of the city. This directly gives credit to the fact that the study is focused on good health and well-being, sustainable cities and responsible material use.

4.2.9 Summary of Qualitative Recommendations

Table 4.14 Main recommendations emerging from interviews

Recommendation Area	Key Suggestions from Participants
Ventilation and occupancy	Improve ventilation during and after renovation; allow off-gassing time before use; delay occupancy after finishing work
Material selection	Use low-VOC paints; choose lower-emission furniture boards and finishes; avoid dust-trapping materials in small spaces
Information and transparency	Encourage product labels; require data sheets; improve public awareness of material safety
Professional practice	Add indoor material criteria to design briefs; create healthier procurement lists; educate designers and clients
Policy and standards	Develop local healthy material guidelines; strengthen indoor material standards; promote regulatory awareness

The recommendations show that participants want both **individual-level** and **system-level** change. They recognize the need for safer consumer choices, but also expect professionals,

suppliers, and authorities to make healthier material decisions easier and more visible.

Summary

the qualitative results indicate that the effects of hidden materials in Lahore interiors are mostly smell, stuffiness, dust, warmth, irritation and less comfort, especially post-renovation or furnishing. Both users and professionals indicated VOCs, poor ventilation, and lack of awareness as critical issues. Another finding of the study was that healthier materials are generally limited by cost and poor labeling, availability and aesthetics. Meanwhile, participants highly endorsed a more responsible approach to the use of materials with enhanced specifications, product information, delayed occupancy, enhanced ventilation, and local guidelines. The qualitative findings thus support the thesis that the indoor environmental health of Lahore interiors is not merely determined by the materials used, but also the manner in which the materials are chosen, installed, ventilated, described and controlled.

5. Discussion

The results in this research indicate that the presence of hidden material effects is also a significant issue of concern in indoor environmental health in Lahore interiors despite its moderate effects being visible instead of severe. In the quantitative findings, the respondents stated that they are particularly worried about strong smell postrenovation, diminished air freshness, potential harmful emissions of finishes and furniture, and the impact of the choice of material on indoor health. This tendency was supported by the qualitative findings indicating that the most frequent reason why participants referred to hidden risk was related to odor, stuffiness, closed rooms, dust, and post-repainting or furniture discomfort. This general tendency can be correlated with the recent studies which indicate that construction and completion materials are the significant sources of VOCs and odors indoors and that the perceived air quality may suffer even when the issue is not visible at the moment. Research on common building materials and PVC-based items also reveals that formaldehyde, n-hexane, VOCs, and SVOCs are

still significant issues in interior settings, particularly following installation or renovation.

A key aspect of this research is that the issue was not confined to a single material or dramatic outcome of health. Rather, the findings indicate a stratified exposure setting. In quantitative terms, wall paint, tiles, upholstered furniture, laminates, MDF, adhesives, PVC finishes, and sealants were the most popular materials. On a qualitative level, participants never characterized these materials alone; they associated them with inadequate ventilation, trapped odor, dust, and heat. This espouses the position that the indoor environmental health is not determined by a single source of pollution, but by an interplay of materials, air movement, temperature and experience of occupants. Recent systematic review findings also come to the same conclusion that construction materials may have an impact on both physical and psychological health, where outcomes have been reported of irritative symptoms, respiratory issues, allergies, and more widespread effects of comfort or stress. The current results are consistent with that literature since the respondents more frequently characterized minor consistent pains and less comfort than acute illness, which is precisely how the influence of concealed contents is expected to manifest itself in a daily interior.

These findings are more important in the context of Lahore. Respondents in the interview kept on making the suggestion that the impact of indoor materials is aggravated by heat, closed interiors and pressure exerted by the environment in an urban setting. The quantitative findings also indicated more concern scores in spaces that were recently renovated and in spaces where more material profiles were predominantly synthetic. This is realistic considering that it is presented in conjunction with the existing body of literature that focuses on Pakistan, and emphasises the necessity of indoor air quality and thermal comfort in Lahore and other large urban areas. In humid and contaminated inner cities, the indoor space can turn to be a compound space of exposure where outdoor pollution, restricted airflow, and material emissions intersect. The

same interpretation explains why the newly renovated interiors in this study seemed less healthy on the whole and yielded more reports of smell and perceived harmful substances. It is argued here that in Lahore, material choice must not be decoupled of climate-responsive ventilation and occupancy management.

The other important point of discussion is the disconnect between awareness and practice. The respondents tended to agree that materials have an influence on health, low-toxicity products should be promoted, and healthier standards and labeling are required. Nevertheless, cost, appearance and market availability were still mentioned by professionals as the primary selection factors with health safety having a low rank. This contradiction was highly supported by the qualitative findings in which the participants noted low product transparency, poor labelling and pressure to fast and attractive finishes. This follows the recent literature that suggests that sustainability in interiors cannot be diminished to look, recycled material or an overall assertion of green. The quality of the indoor environment should also consider the measurable health performance, human toxicity, and informed material specification. Responsible material use in this sense, involves not only superior products, but superior decision systems and procurement criteria, and user awareness.

6. Conclusion

This paper finds that material impacts are a significant yet frequently overlooked aspect of interiors environmental health in Lahore interiors. The findings in general indicate that the interior materials should not be thought of solely on the basis of beauty, cost, or durability since they also affect the freshness of the air, smell, comfort, thermal conditions, and daily health experience of occupants. The quantitative and qualitative findings suggest that most of the interior spaces in Lahore feature mixed and synthetic products like paints, laminates, MDF, adhesives, PVC finishes, sealants, and upholstered furniture, which can cause hidden environmental burdens when

coupled with inadequate ventilation, heat, dust, and dense urban environments.

It also indicates that effects of such materials are usually indirectly felt in form of symptoms like headaches, eye irritation, fatigue, breathing discomfort, stuffiness, and general reduction in comfort as opposed to direct destruction. This renders the problem particularly significant, as latent risks may go undetected in the long term by the users. The findings also show that healthier material usage is increasingly being aware of, although costly, appearance, limited product information, and poor access to safer versions all still dominate practical decision-making. The issue is not purely technical, but also educational, professional and policy-based, in this sense.

One of the significant contributions of the research is that it links the interior material selection to the broader objectives of good health and well-being, sustainable cities, and responsible use of materials. The healthier the interior is, the healthier the people and the individual choice of materials can lead to the creation of more sustainable and habitable urban areas in Lahore. Thus, the paper focuses on the fact that interior design has to go beyond the surface beauty, and become more knowledgeable, health conscious and environmentally conscious. Altogether, the paper concludes that the enhancement of the indoor environmental health in Lahore needs more awareness, better material transparency, healthier design practices, and better guidance to responsible choices of interior materials.

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