Managing the invisible: the role of air quality in the hospitality industry

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International Journal of Contemporary Hospitality Management

213

Received 14 October 2024
Revised 29 January 2025
10 April 2025
9 June 2025
Accepted 9 June 2025

Abstract

Purpose – This paper aims to critically reflect on the relevance of indoor air quality (IAQ) in the hospitality industry and propose future research pathways. This study extracts four main perspectives from the literature about the impact of IAQ – i.e. premise, employees, customers and business – and illustrates the importance of this issue in the post-pandemic and broader sustainability context.

Design/methodology/approach – Based on a semi-systematic literature review, this study clusters a comprehensive body of research in two ways: first through an analysis of keyword co-occurrence patterns and second through an alignment with the three pillars of sustainability. Thus, this paper identifies relevant streams of literature to outline the current impact of IAQ in the hospitality sector. This study discusses and synthesizes several management theories to identify future research directions and propose effective IAQ management strategies.

Findings – Despite the post-pandemic attention to health issues in indoor environments, IAQ remains under-researched in the hospitality management literature. Inadequate IAQ can lead to health consequences, either acute or chronic, that negatively affect guest satisfaction and loyalty; thus, an effective IAQ management can enhance a hotel's reputation and attract eco-conscious customers. Technological solutions, such as sensors and smart heating venting and air conditioning systems, may improve IAQ while ensuring energy efficiency and cost management.

Research limitations/implications – This study is based on a semi-systematic literature review, which may limit the generalizability of the findings. This study outlines several pathways for future research, including longitudinal studies, cross-cultural comparisons and empirical assessments of the economic and behavioral impacts of IAQ improvements in hospitality premises.

Originality/value – This paper thoroughly examines IAQ within the hospitality industry, connecting the topic with broader sustainability and management frameworks. It provides a roadmap for future research that can support the scientific conversation at both the academic and managerial levels, ideally leading to the development of effective IAQ management strategies.

Keywords Indoor air quality, Guest satisfaction, Sustainability, Experience management, Air quality technologies, Corporate social responsibility

Paper type Conceptual paper

Introduction

Indoor air quality (IAQ) is a critical component of environmental quality in indoor environments. Although the issue is often overlooked, the hospitality industry increasingly recognizes IAQ as essential to experience management. Chan's (2012) foundational work established IAQ as a determinant of guest satisfaction, highlighting its role in sustaining operational and environmental performance in hospitality premises. While this research

International Journal of Contemporary Hospitality Management
Vol. 37 No. 13, 2025
pp. 213-233
Emerald Publishing Limited
0959-6119
DOI 10.1108/IJCHM-10-2024-1504

stream has struggled to gain traction amidst other aspects of hospitality management, the COVID-19 crisis placed a fresh spotlight on poor air quality. In that context, poorly ventilated and overcrowded areas proved to be ripe for infection outbreaks, ultimately leading to more illness and death. Even outside of the pandemic, air pollution is considered responsible for a loss of life expectancy comparable to smoking tobacco and its impact exceeds that of infectious diseases at the global level.

As societies become more attuned to a range of health and sustainability issues, consumers are factoring air quality into their satisfaction and overall experience ratings of hospitality venues (Liu *et al.*, 2022; Tan *et al.*, 2023; Villeneuve and O'Brien, 2020). This trend aligns with the growing body of research on pro-environmental behaviors in hospitality, which underscores the importance of environmental quality – including IAQ – as a driver of both individual actions (Mansoor *et al.*, 2025) and organizational outcomes (Lin *et al.*, 2022). Even during short stays, poor IAQ can give rise to immediate adverse effects, such as allergic reactions, fatigue, headaches and respiratory issues. By significantly detracting from the guest experience, poor IAQ can prompt negative reviews (Villeneuve and O'Brien, 2020) and reduced return intentions. In short, overlooking IAQ management can lead to negative customer experiences and threaten business competitiveness in the long run.

In the hospitality sector, where business success is deeply intertwined with the guest experience, there is strategic value in comprehensively addressing sustainability-related factors. Technological innovations play a significant role in this regard, supporting the customer experience (Agapito and Sigala, 2024), improving operations efficiency, developing targeted services and promoting sustainability at large. However, customers may not perceive some sustainability practices as directly relevant to their experience or well-being. This is the case of improvements in IAQ, which are often *invisible* by their nature. Thus, they may not be valued as highly as more apparent sustainability efforts, such as green walls or plastic-free environments.

Nevertheless, managing IAQ is a contingent challenge in the hospitality industry, which is characterized by a high density of transient populations and diverse activities that impact air quality, such as inadequate ventilation, emissions from cleaning agents, building materials and furnishings, as well as outdoor pollutants that infiltrate indoor spaces. In this context, enhanced IAQ may significantly improve guests' perceived comfort and satisfaction, leading to higher guest retention rates and positive reviews. Moreover, addressing IAQ aligns with broader sustainability goals and international regulatory standards, positioning hospitality firms as responsible actors adhering to a corporate sustainability strategy (CSS) (Guerra-Lombardi *et al.*, 2024). By assimilating long-term sustainability into their core business strategy, hospitality firms may also build resilience against future crises, regulatory changes and shifts in consumer preferences.

To capitalize on these challenges and find new opportunities, hospitality managers must define a clear roadmap for investment in sustainability practices. To this end, they need to manage the *invisible* and *intangible* by prioritizing compliance with regulatory standards while seeking competitive advantages in the market. Investments in advanced IAQ monitoring and management technologies, sustainable building materials and comprehensive maintenance programs can differentiate a hospitality business in this highly competitive industry sector. Moreover, by promoting and effectively communicating these sustainability initiatives, hotels can attract environmentally conscious guests, enhance their own brand reputation and ultimately achieve business success.

Consequently, managing IAQ requires an evidence-based and holistic approach encompassing both the structural and behavioral levels of hospitality management. Building

upon previous studies (e.g. Chan, 2012), this paper aims to critically reflect on the importance of IAQ in the hospitality sector. Specifically, we examine the extant literature and propose future research pathways for addressing this essential aspect of guest experience management. This study extends Chan's (2012) research by integrating recent technological advancements, sustainability practices and behavioral management theories. By systematically framing IAQ within broader management paradigms, our work seeks to build a solid theoretical foundation for this topic while proposing actionable pathways for improving IAQ in hospitality settings. Our hope is that the insights generated herein will be translated into effective IAQ strategies that bolster guest satisfaction and support sustainable business practices.

The remainder of the paper is organized as follows: Section 2 describes the methodology behind the literature review; Section 3 describes the sample of identified literature; Section 4 presents the results of our literature analysis; Section 5 discusses the main streams of research identified and suggests pathways for future research; finally, Section 6 concludes by summarizing the study's insights for managers and academia.

Methodology

We conducted a semi-systematic literature review (Snyder, 2019). Initially, we accomplished a general search using the research string to code for the core concept, i.e. "indoor air management hospitality" across leading several academic databases (i.e. Web of Science, ProQuest, Scopus, ScienceDirect and Taylor & Francis Ed.).

The search string included a combination of terms to be applied to the title (i.e. ("air quality management" OR "indoor air quality" OR "air quality") AND ("hospitality" OR "hospitality industry" OR "hospitality sector" OR "hotel*") AND ("management practices" OR "sustainability" OR "operations")) and to the topic/subject of the studies (i.e. "air quality management" OR "indoor air quality") AND ("hospitality" OR "hospitality industry" OR "hospitality sector" OR "hotel*").

This approach returned 216 articles published between 1995 and 2024. Next, we adopted a snowballing technique – wherein we extracted additional relevant studies from those initial articles' references – to uncover a broader array of research related to IAQ management in the hospitality sector. This iterative process ensured a comprehensive investigation of the academic conversation, capturing both foundational studies and recent developments.

We first extracted keywords from the identified papers, clustered them based on their co-occurrence, and then analyzed them with the VOSviewer software to identify the field's evolution, the most relevant research streams and the prominent gaps.

Literature review

The hospitality literature has investigated environmental management with different lenses (Chan and Hsu, 2016), such as sustainability, cost management and customer behavior and orientation. Among these aspects, IAQ has received limited attention so far in hospitality facilities, particularly hotels, in terms of the number of empirical studies developed, areas covered and the time span of the investigations (Chan, 2012). This is mainly attributable to a generalized lack of attention to IAQ in recent years and the sector's low interest in the topic. Research in this domain did not expand until the late 20th century, driven by efforts to study the benefits of regulations on smoke-free indoor environments (Chan and Hsu, 2016). However, the stream then morphed into a more general conversation about hygiene and the cleaning of premises.

Our longitudinal analysis of keywords (as visualized in the bibliometric network reported in Figure 1) reveals the evolution of research priorities and interconnections. Central themes

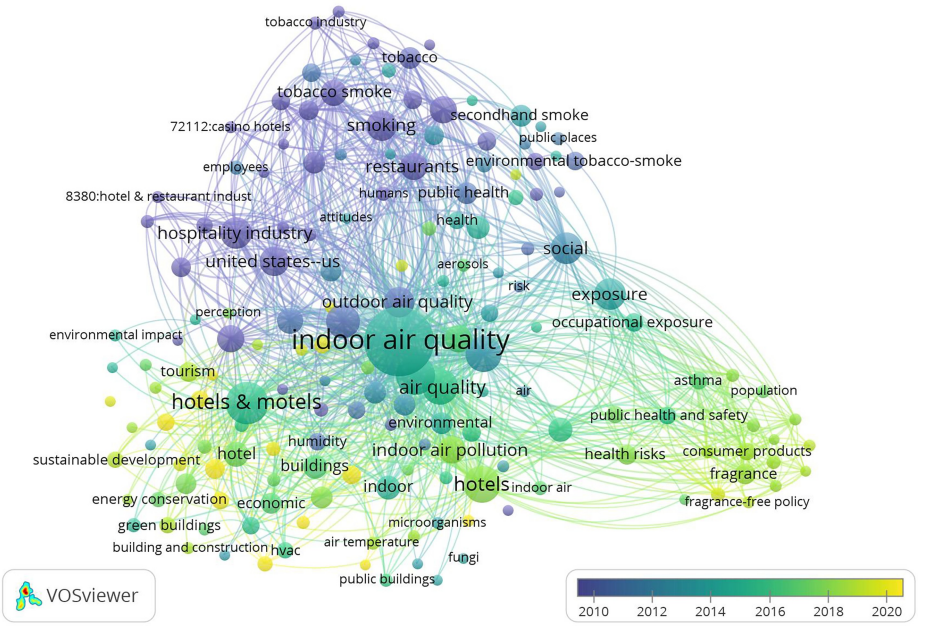


Figure 1. Longitudinal analysis of keywords
Source: Authors' own work on VOSviewer

such as "indoor air quality," "hotels and motels" and "hospitality industry" are prominent, reflecting the field's progression. The early emphasis on health-related topics, including "secondhand smoke" and "public health," has gradually expanded to encompass broader environmental concerns, such as "sustainable development," "green buildings" and "energy conservation." This shift highlights the growing alignment of IAQ management with global sustainability agendas and technological advancements in building systems, congruent with firms' mounting attention to these topics. Notably, the emergence of terms like "fragrance-free policy" and "consumer products" underscores the increasing attention to guest preferences and perceptions. These trends suggest a maturing research field integrating IAQ's health, environmental and economic dimensions, underscoring its strategic importance for the hospitality sector.

The geographic scope of IAQ research mirrors distinct temporal trends. Studies conducted in the USA dominate the earlier period, focusing on public health issues such as second-hand smoke and regulatory frameworks that address smoking in hospitality settings. The later period, by contrast, is characterized by a growing body of research centered on China and Taiwan, reflecting the heightened awareness of IAQ challenges in rapidly urbanizing regions that are exposed to intensive outdoor air pollution, yet characterized by large hotel and tourism industries. This shift may also reflect increasing investment in IAQ technologies and stricter air quality regulations in East Asia, where air pollution has emerged as a critical societal concern, as already pointed out by Chan (2012). The geographic evolution of IAQ research reflects the dynamic interplay between local priorities and global trends, suggesting the need to further explore IAQ management practices in other regions to achieve a more comprehensive understanding of its implications for the hospitality sector.

The complete list of papers included in this review is reported in the Supplementary Material.

Beyond the longitudinal dimension, the sampled literature can also be divided into two main literature streams: premise-centric studies focusing on the characterization of IAQ in hospitality environments, which are mainly developed through empirical investigations; and customer-centric studies exploring the relevant aspects of guests' experience in hospitality premises, among which IAQ is accounted.

2.1 Empirical characterization of IAQ in hospitality

Among premise-centric studies, empirical investigations focus on detecting pollution conditions and sources of contamination in hospitality environments. They basically agree on the key parameters for assessing IAQ, which align with Green Building certification schemes for corporate and hospitality buildings. These articles emphasize the importance of monitoring pollutants – like carbon dioxide (CO_2), particulate matter in the class of 10 microns and 2.5 microns (i.e. PM10, PM2.5) and volatile organic compounds (VOCs) – to maintain high IAQ standards.

Table 1 summarizes the elements of interest of each study analyzed.

Lee *et al.* (2001) conducted one of the earliest studies, examining particulate matter levels in restaurants and identifying high-heat cooking methods as significant contributors to poor air quality. Later studies by Wallace and Ott (2011) and Ott *et al.* (2017) reinforced these findings by highlighting the health risks posed by different cooking styles and the need for effective IAQ management.

Chan *et al.* (2009) evaluated IAQ in newly opened hotels, identifying emissions from indoor sources, such as furniture, as major contributors to poor air quality. Further research by Chan *et al.* (2015, 2017) examined the impact of cigarette smoke and air purifiers on IAQ, ultimately suggesting mitigation strategies like improved ventilation and air purification technologies. These studies underscore the importance of continuous IAQ monitoring and management in maintaining healthy indoor environments.

This stream of literature repeatedly noted the lack of information and training on IAQ management within the hospitality sector. For instance, Asadi *et al.* (2011) highlighted this gap through a case study that proposed an IAQ audit approach for hospitality premises. Their comprehensive assessment included standard chemical and physical parameters as well as biological indicators like bacteria, fungi and Legionella. The study identified insufficient ventilation and high PM concentrations as key elements of concern, recommending equipment retrofits, cleaning procedure modifications and air filtration system improvements to enhance IAQ.

He *et al.* (2016) further emphasized the issue of poor ventilation in hotel guestrooms through a study of four hot spring hotels in Guangdong, China. This research measured indoor pollutants, including carbon dioxide, Co., PM10, PM2.5 and VOCs, during the summer. The results linked high carbon dioxide levels with inadequate air exchange and variations in PM concentrations to specific indoor activities. The study employed principal component analysis to determine that indoor factors, such as building materials and cleaning products, significantly impacted IAQ more than outdoor pollution.

Extending these investigations to broader hospitality environments, Chang *et al.* (2020) focused on the impact of specific guest and staff activities on PM2.5 concentrations in hotel rooms. Their targeted experiment – involving three US hotels – found that activities like walking, cleaning, and showering significantly affected PM levels. Thus, the authors suggested that cleaning staff, in particular, should be adequately equipped to mitigate their exposure to chemical agents. This study also highlighted the opportunity for hotels to

Table 1. Review of relevant studies focusing on IAQ characterization in hospitality premises

Authors	Journal	Year	Type of study	Parameters of interest	Areas	Testing period
Zanni *et al.*	*Intern. J. Hosp. Manag.*	2022	Empirical investigation of IAQ in a hotel premise in Italy	Temperature, Humidity, PM2.5, VOC, CO_2	Guestrooms, hall, kitchen, restaurant and fitness center	Six months
Chang *et al.*	*Intern. J. Hosp. Manag.*	2021	Empirical investigation of IAQ in an open kitchen restaurant in the US	PM10, PM2.5	Open kitchen	1 week, monitoring limited to 2 h per day
Chang *et al.*	*Intern. J. Contemp. Hosp. Manag.*	2020	Empirical investigation of IAQ in hotel guestrooms of three hotels in Southwest US	PM2.5	Guestrooms	1 night for each of the three hotels
Chan *et al.*	*Intern. J. Hosp. Manag.*	2017	Empirical investigation of the impact of cigarette smoking in a hotel in Northern China	PM2.5	Guestrooms	150 min
Ott *et al.*	*Ind. Air*	2017	Empirical investigation of IAQ into grill restaurants in the USA	PM2.5	Dining areas	2 h
He *et al.*	*Atmos.*	2016	Empirical investigation of air pollution condition in occupied guestrooms of four hot spring hotels in China	CO, CO_2, Radon, VOCs, PM2.5, PM10	Guestrooms	1.5 h
Chan *et al.*	*Intern. J. Hosp. Manag.*	2015	Empirical investigation of the impact of air cleaners in a hotel in China	CO_2, TVOCs, PM2.5, bacteria and fungi	Guestrooms	4 days

(*continued*)

Table 1. Continued

Authors	Journal	Year	Type of study	Parameters of interest	Areas	Testing period
Asadi *et al.*	*Build. and Env.*	2011	Empirical investigation of IAQ in different areas in a hotel in Portugal	Temperature, humidity, air exchange rates (AERs), CO, CO_2, Formaldehyde, VOCs, PM2.5, PM10, biological indicators (bacteria, fungi, Legionella)	Guestrooms, conference rooms, restaurant, reception, lobby	Short-term assessment
Wallace and Ott	*J. Exp. Scie. and Env. Epid.*	2011	Empirical investigation of IAQ into 22 restaurants in the USA	PM1	Dining areas	2 h
Chan *et al.*	*Intern. J. Hosp. Manag.*	2009	Empirical investigation of IAQ in hotel guestrooms in a manufacturing region in China	Temperature, humidity, ventilation rate, individual VOC, TVOC	Guestrooms	2 days
Lee *et al.*	*Sci. Tot. Env.*	2001	Empirical investigation of IAQ into restaurants in Hong Kong	CO, CO_2, formaldehyde, VOCs, PM2.5, PM10	Dining area	2 h

Source(s): Authors' own work

develop a competitive advantage by actively monitoring and improving IAQ to meet growing guest expectations, especially in the post-pandemic context where cleanliness and safety have become paramount.

The COVID-19 pandemic has indeed renewed interest in IAQ, with studies by Chang *et al.* (2020) and Zanni *et al.* (2022) advancing the critical need for effective IAQ monitoring and management. These studies revealed concerning air pollutant concentrations in dining and other hotel areas, emphasizing the health risks and the competitive advantage that could result from maintaining high IAQ standards. They also stressed the importance of real-time IAQ monitoring systems to meet both management needs and guest expectations.

2.2 The role of IAQ in experience management in hospitality

The primary focus of the hospitality industry is to ensure that guests have a positive experience that leads to satisfaction and loyalty. Thus, researchers widely use social media, online reviews, surveys and questionnaires to gather insights into travelers' experiences. In the last few years, especially, Data Science and Artificial Intelligence (AI) tools have allowed for big data collection and analysis. Three seminal studies by Zhang *et al.* (2020), Yang *et al.* (2022) and Tan *et al.* (2023) explored the impact of outdoor air pollution on tourists' behaviors, traveling decisions and satisfaction using econometric regression, sentiment analysis and big data approaches. These studies confirmed the negative effects of air pollution on tourist experiences and advanced that clean air is critical for enhancing guest satisfaction.

Moving from outdoor to indoor environments, Villeneuve and O'Brien (2020) applied text-mining techniques on Airbnb reviews to identify complaints related to Indoor Environmental Quality (IEQ), which encompasses not only IAQ, but also visual, acoustic and thermal comfort elements. Their findings underscore the critical role of IEQ in building overall guest satisfaction: In their case, even a small number of complaints significantly impacted review scores. Focusing on sleep quality, which represents a key element of the hotel guest experience, Mao *et al.* (2018) developed a conceptual framework for evaluating sleep-related factors in hotel rooms, such as noise, light, temperature, bedding and air quality. Their framework aligns with findings from Xiong *et al.* (2020), who affirmed the importance of a clean and comfortable environment for better sleep quality and overall well-being. These studies collectively suggest that good IAQ is integral to guest comfort and satisfaction.

Moreover, considering the perception of cleanliness as an additional critical aspect of the guest experience, this research stream has linked IAQ to factors like lighting, greenery within the premise, surface (such as flooring and furniture) shininess, presence of ambient scents and visible cleaning staff (Magnini and Zehrer, 2021). Future research needs to investigate how much this perception overlaps with actual cleanliness, namely, by linking perceptions with concrete measurements of IAQ (i.e. from the monitoring and display of environmental parameters). Table 2 reports the most relevant customer-centric studies that we identified.

Results

The bibliometric network analysis generated through VOSviewer identified four distinct thematic clusters and a smaller sub-cluster within the literature on IAQ management in hospitality (Figure 2). We categorized these clusters based on keyword co-occurrence patterns and provide insight into the main focus of research developed in the field.

The first cluster delves into Health and Tobacco Smoke Concerns (Green Cluster in Figure 2). This cluster predominantly addresses public health issues, particularly related to second-hand smoke and tobacco use in indoor environments. Early studies, primarily focused on the USA, explore the health risks associated with exposure to environmental

Table 2. Review of relevant studies focusing on customer experience related to IAQ

Authors	Journal	Year	Focus of the study	Methodology	Data
Tan *et al.*	*Current Issues in Tourism*	2023	Outdoor environment	Negative binomial model (N) and panel corrected standard errors (PCSE)	Air quality data and tourist flow data, secondary (cellphone data)
Yang *et al.*	*Tourism Management*	2022	Outdoor environment	Text mining; big data analysis structured as a five-way-fixed-effects model	Secondary: TripAdvisor reviews
Magnini & Zehrer	*International Journal of Hospitality Management*	2021	Indoor environment	Literature review	Secondary: literature data
Villeneuve and O'Brien	*Building and Environment*	2020	Indoor environment	Text-mining	Secondary: 1.35-million Canadian Airbnb reviews
Xiong *et al.*	*International Journal of Hospitality Management*	2020	Indoor environment	Questionnaire; binary logistic model	Primary: Data on sleep quality by 505 Chinese travelers
Zhang *et al.*	*Annals of Tourism Research*	2020	Outdoor environment	Text mining; econometric regression and sentiment analysis	Secondary: over 13 million geotagged posts from Weibo (China's equivalent of Twitter)
Mao *et al.*	*International Journal of Hospitality Management*	2018	Indoor environment	Text-mining; logit regression	Secondary: Reviews of hospitality facilities in Los Angeles published on TripAdvisor

Source(s): Authors' own work

tobacco smoke in hospitality settings, such as hotels and restaurants. Keywords like "tobacco smoke," "secondhand smoke" and "public health" reflect the regulatory discussions and health advocacy efforts during the early 1990s and 2000s. The studies in this cluster frequently examine the role of policies and interventions, such as smoking bans and air filtration systems, in mitigating health risks.

The second cluster addresses the specificity of the Hospitality Industry and Infrastructures (Red Cluster in Figure 2). This cluster emphasizes the interplay between IAQ and facility management, particularly in the hospitality industry. Recurrent keywords such as "hotels and motels," "tourism" and "sustainable development" reflect the economic and experiential dimensions of IAQ management. Studies in this cluster investigated how air quality is related to buildings and infrastructure, discussed the assimilation of IAQ initiatives into broader sustainability frameworks, and explored concepts such as green buildings, energy conservation and environmental impact.

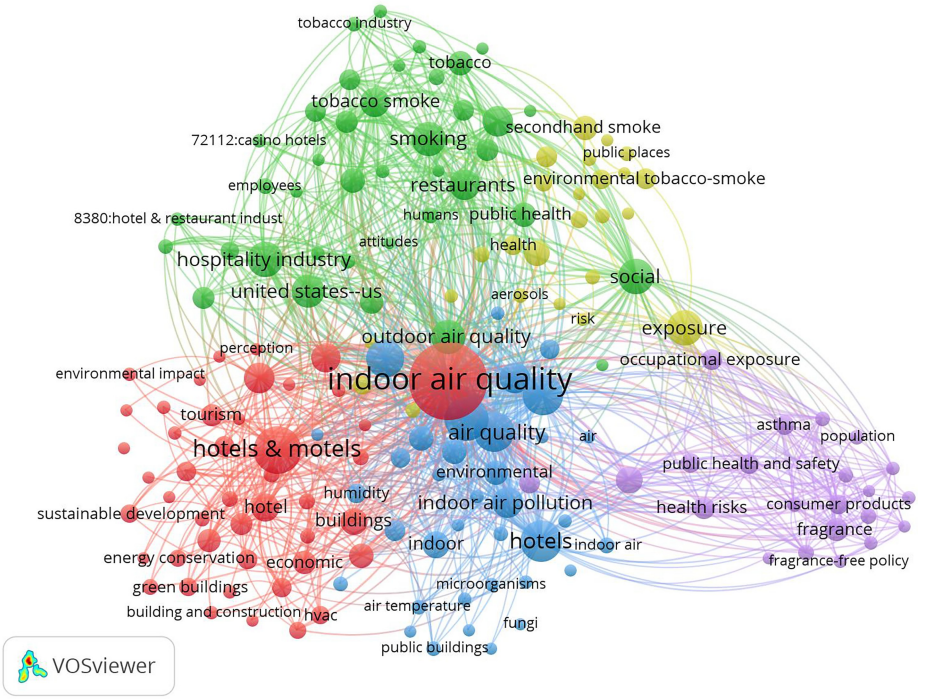


Figure 2. Clustering of the IAQ in hospitality management literature: health and tobacco smoke concerns (green cluster); hospitality industry and infrastructures (red cluster); environmental pollution (blue cluster); consumer preferences (purple cluster)
Source: Authors' own work on VOSviewer

The third cluster (Blue Cluster in Figure 2) orients around Environmental Pollution. The research in this cluster highlights technological advancements and their implications for IAQ management. Keywords such as "indoor air pollution," "humidity" and "air temperature" point to technical approaches for improving air quality in indoor environments, with particular emphasis on pollutants of concern: namely, microbial pollutants and particulate.

The fourth cluster (Purple Cluster in Figure 2) elaborates upon Consumer Preferences, investigating consumer perceptions of IAQ and the influence of policies such as fragrance-free initiatives. Keywords like "health risks," "consumer products" and "fragrance" suggest an emerging focus on addressing guest sensitivities and preferences, with the goal of promoting positive guest experience and satisfaction. The stream of literature explores how tailored IAQ strategies, including allergen control and chemical emissions management, can enhance customer satisfaction and promote wellness.

Finally, we identified a sub-cluster (Yellow Cluster in Figure 2) at the interface between Tobacco smoke-related concerns and consumer products orientation. This sub-cluster focuses on the Exposure dimension of IAQ and health risks carried by aerosols and ultrafine particles.

The identified literature can also be alternatively clustered around the three pillars of sustainability: social, environmental and economic dimensions. The social dimension

emerges as the most developed pillar, with significant attention given to health-related issues such as exposure to secondhand smoke and its associated risks [see Figure 3(a)]. Studies within this cluster examine the impacts of smoking policies, occupational exposure and public health interventions, reflecting broader concerns about societal well-being and regulatory responses. The environmental pillar, by contrast, focuses on indoor pollutants, including aerosols, allergens and chemical emissions, with studies emphasizing their sources, mitigation strategies and the role of air monitoring systems in enhancing environmental health [see Figure 3(b)]. Finally, the economic dimension is primarily related to buildings, exploring the financial implications of IAQ interventions in terms of energy efficiency, sustainable building design and operational costs [see Figure 3(c)]. This cluster highlights the economic opportunities and challenges of integrating IAQ improvements into the built environment. Addressed together, these pillars may generate a holistic approach to IAQ management in hospitality, with the social dimension leading the discourse while environmental and economic considerations offer critical complementary insights.

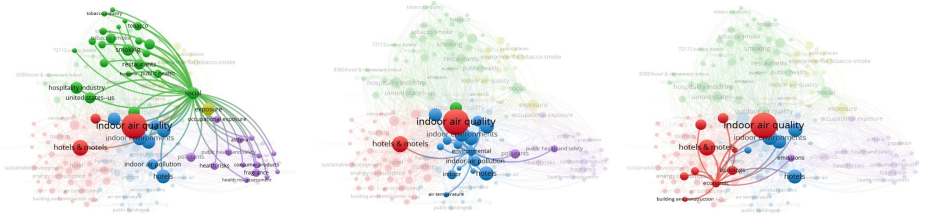
Discussion

The hospitality industry – and concurrently, the academic literature – is increasingly recognizing the significant influence of IAQ on guest health, satisfaction and overall business performance. This section incorporates insights from empirical studies and theoretical frameworks to highlight pathways for future research and management practices, which may address the challenge of IAQ invisibility compared to more tangible sustainability-oriented initiatives.

Pathways for future research

The study of IAQ management in the hospitality industry has evolved almost spontaneously, moving from a phenomenological approach to a more structured discipline rooted in management theories. We identified four pivotal perspectives in the literature: premises, employees, customers and business.

First, considering the infrastructural dimension as the *condition sine qua non*, future research should explore the premises' perspective in a structured way so as to build the backbone of IAQ management (i.e. encompassing infrastructure, technologies and operational systems). Integrating the framework for systematic IAQ assessment proposed by Zanni *et al.* (2022) with the broader perspective offered by Chan (2012), we suggest a structured approach to IAQ monitoring that can coordinate with operations and stakeholder



(a) **(b)** **(c)**

Figure 3. Sustainability dimensions of IAQ in hospitality management literature, namely, (a) social, (b) environmental and (c) economic

Source: Authors' own work on VOSViewer

management. Several studies (Chan *et al.*, 2021; Pillai *et al.*, 2021; Zanni *et al.*, 2022) demonstrate the potential of new technologies to provide real-time IAQ data and improve IAQ outcomes. Research should focus on identifying the most compelling emerging technologies, such as the Internet of Things (IoT) and AI, and how they integrate with existing IAQ management systems like HVAC to ensure the best guest experience and the most cost-effective on-premise performance. For instance, a continuous monitoring system applied in the different areas of hospitality premises, through low-cost sensor networks ensuring sufficient reliability, may support long-term data collection. This activity can generate first-hand data that AI-based algorithms could then use to derive advanced information about IAQ drivers, identify patterns and infer possible interventions and their impact – both at the technological and managerial level (Mariani and Wirtz, 2023; Shu *et al.*, 2024). Regarding the technological level, IoT solutions may provide IAQ data with positive feedback to regulate HVAC systems. As Dai *et al.* (2023) highlighted, empirical investigations have testified to the intrinsic challenge of balancing the traditional IAQ demand for ventilation with the effort to save energy, the latter of which typically requires better building insulation. This leads to a trade-off between promoting energy efficiency (i.e. the ability of the system to deliver optimal environmental conditions with minimum energy input) and IAQ management, which is only partially addressed by IoT solutions (Dai *et al.*, 2023)). Integrating IoT and AI-based algorithms may ultimately help overcome the apparent eternal struggle between IAQ and energy efficiency by proactively optimizing the HVAC system based on real-time data and customer demand. This integration may generate value by recommending proactive maintenance that can minimize downtime (i.e. periods during which the system is not operating effectively, potentially due to maintenance issues, malfunctioning or sensor recalibration needs), thereby promoting energy efficiency and well-being in the indoor environment at the same time (Elkhwesky and Elkhwesky, 2023). Future research should evaluate how IAQ management can be integrated into broader environmental management systems (EMS) within hospitality settings. Identifying the key IAQ components that contribute to overall environmental performance can demonstrate how comprehensive IAQ management supports a broader approach to sustainability practices. By elaborating on EMS, which provides a framework for systematically managing environmental aspects, researchers can show how incorporating IAQ as a central element can lead to overall sustainability performance and better regulatory compliance (Chan and Hsu, 2016).

Second, researchers should more deeply explore the employees' perspective. For instance, scholars could merge several frameworks to clarify how behavioral interventions (e.g. educational and communication strategies) can improve IAQ management. The first framework, the theory of planned behavior (TPB) (Ajzen, 1991), states that individual behavior is driven by intentions, which are influenced by attitudes, subjective norms and perceived behavioral control. The second framework – green human resource management (GHRM) (Kramar, 2014) – focuses on implementing HR practices that encourage pro-environmental behavior. TPB can help identify the psychological factors that motivate or hinder compliance with IAQ practices, while GHRM can ensure that these practices are embedded into the organizational culture. The third framework – the total quality management (TQM) theory (Deming, 1986) – provides a complementary perspective by emphasizing continuous improvement and a strong focus on employee involvement and training. As hospitality middle management come to appreciate air quality as a key sustainability practice (Guerra-Lombardi *et al.*, 2024), TQM principles can guide the development of organizational cultures that prioritize IAQ improvements, embedding these practices into quality management systems that align with the broader CSS.

For example, empowering employees with knowledge and skills through targeted training can enhance compliance with IAQ protocols and drive collective ownership of IAQ goals. Emerging approaches, such as avatar-led green training, have shown potential for enhancing environment-related organizational citizenship behaviors and fostering green creativity (Hao *et al.*, 2025). The fourth framework, the technology acceptance model (TAM) (Davis and Davis, 1989), adds further depth by addressing the determinants of technology adoption – particularly, perceived usefulness and ease of use. TAM underscores the importance of designing IAQ technologies – such as IoT-based sensors and advanced monitoring and display systems – that are intuitive and demonstrably beneficial in improving air quality. These two elements (i.e. ease of use and usefulness) can significantly increase employees' willingness to adopt and consistently use IAQ technologies (Aini *et al.*, 2024). Finally, the dynamic capabilities theory (DCT) (Teece *et al.*, 1997) highlights the need for hospitality firms to *sense and seize* technological opportunities and transform their management modes to maintain a competitive advantage. The application of DCT in the context of IAQ management can lead to practical guidelines that not only enhance guest satisfaction through better IAQ, but also improve operational efficiency by streamlining IAQ management processes. These theories can guide the development of effective IAQ management protocols through targeted education, training and communication strategies, ultimately leading to sustained compliance and improved IAQ. Moreover, these strategies may reinforce broader pro-environmental behaviors among staff, as shown by Lin *et al.* (2022), further embedding IAQ management into sustainable organizational practices. Studies such as Chan *et al.* (2015) highlight the impact of communication, education and practice on pro-environmental and IAQ management. Future research should focus on experiments involving staff and guests to verify the effectiveness of these interventions.

Moreover, research should build upon the sub-cluster identified in the extant literature by exploring the impact of IAQ on employees themselves. Unlike transient guests, who are exposed for short durations, employees face prolonged exposure to poor IAQ, which may lead to chronic health issues such as respiratory disorders, fatigue and decreased productivity. Future research should prioritize multidisciplinary and longitudinal studies to assess the cumulative health impacts on hospitality workers and explore interventions tailored to improve their working environments. This can include examining the effectiveness of ventilation systems, protective measures and training programs on IAQ awareness. Addressing employee well-being is critical to enhancing job satisfaction, retention and overall organizational performance.

Third, and following previous studies (e.g. Chan, 2012; Zanni *et al.*, 2022), research needs more assessments of the guest perspective. Longitudinal study results are essential for evaluating the long-term effects of IAQ improvements on guest health and satisfaction. Several studies (Aksu *et al.*, 2021; Yang *et al.*, 2022) already highlight the importance of IAQ improvements in maintaining high levels of guest satisfaction and loyalty, which they uncovered via customer satisfaction questionnaires and social network analyses. Further research should explore the long-term effects of IAQ improvements across different demographic groups – such as business versus leisure travelers or different age classes and educational levels – and how these effects influence the overall guest experience and loyalty. Moreover, IAQ-related initiatives, if effectively communicated, may serve as behavioral cues that trigger environmentally responsible behaviors among guests, echoing findings on the role of green practices and social influence in fostering eco-friendly customer behaviors (Mansoor *et al.*, 2025). However, IAQ presents a particularly relevant case of the intention–behavior gap, where guests may endorse sustainability in principle, but fail to

value or act on less *visible* initiatives unless appropriately framed and communicated (Khan *et al.*, 2024). On the one hand, the cognitive consistency theory (Festinger, 1997) can help explain how consistent IAQ improvements foster guest loyalty and satisfaction, as it suggests that individuals seek consistency in their beliefs and attitudes. Consequently, guests who experience consistently good IAQ should be prone to developing a positive attitude toward the hotel, leading to the intention to return and spread positive word of mouth (i.e. positive online reviews in the globalized world of hospitality). On the other hand, cross-cultural comparisons can reveal how different cultural backgrounds influence perceptions of IAQ. Hofstede's cultural dimensions theory (Hofstede, 1980) may provide a basis for understanding these differences by identifying key dimensions of culture that influence behavior – or more relevantly for IAQ, perceptions. Understanding these cultural differences can facilitate tailored IAQ management strategies that improve guest satisfaction and loyalty in different contexts and markets. This can help hospitality managers recognize and address international guests' varying expectations and preferences, as suggested by Zhang *et al.* (2020) and Villeneuve and O'Brien (2020). For instance, guests from cultures with high uncertainty avoidance may place greater importance on visible IAQ management practices, such as clear information about IAQ and air purifiers, than other cultures. Future research could engage in cross-country investigations through questionnaires and planned experiments to assess the impact of cultural factors on IAQ perception.

Fourth, scholars should analyze the economic implications of IAQ improvements to build a business case for these initiatives. There is already some evidence that effective IAQ management can enhance a business' reputation and appeal to environmentally and health-conscious guests. The resource-based view (RBV) (Barney, 1991) can demonstrate the maintaining high IAQ has strategic value in terms of enhancing guest satisfaction and loyalty, and ultimately creating a competitive advantage. Moreover, researchers could extend the triple bottom line (TBL) (Elkington, 1997) framework – which typically evaluates a company's performance based on social, environmental and economic factors – to include IAQ management. The resulting cost-benefit analyses can help build a strong business case for IAQ investments, demonstrating enhanced financial performance through increased guest retention, positive reviews and better energy management (Balaji *et al.*, 2019). Future studies should compare IAQ and energy management results to better quantify these benefits.

The future research pathways identified are detailed in the Supplementary Materials, organized by the four perspectives, i.e. premise, employees, customers and business. For each perspective, research pathways, theoretical background and foundations studies are reported, alongside with suggested research questions, potential contributions, investigation methods and data, to support future research in the field.

The interlinking of these perspectives – premises, employees, customers and business – may form a cohesive framework for advancing IAQ management in the hospitality industry: Optimized premises enhance both guest satisfaction and employee well-being, which in turn strengthen business performance and sustainability. For this reason, research should seek to integrate these perspectives, exploring the technological and psychological dimensions in tandem to maximize insights and impacts. One promising avenue lies at the intersection of the premise and customer perspectives: namely, extending the servicescape theory (which highlights the impact of the physical environment on customer behavior; Bitner, 1992) to include the health benefits of improved IAQ. This approach can provide a comprehensive view of how physical environmental factors contribute to guests' well-being and experience. Future research may also leverage the experience economy framework (Joseph and Gilmore, 1998) to examine the interplay between the customer and business perspectives. This framework suggests that businesses must be able to create memorable events for their

customers to deliver value; thus, researchers could explore how IAQ improvements actually enhance guest experiences. Identifying the specific elements of IAQ that most significantly impact guests' perceived value and satisfaction can help link IAQ improvements with sleep quality, comfort and overall guest experience. Those IAQ enhancements allow hotels to create a distinctive experience that differentiates them from competitors. Studies like Mao *et al.* (2018), Villeneuve and O'Brien (2020) and Xiong *et al.* (2020) suggest that good IAQ is linked to better sleep quality, which is crucial to overall satisfaction. Likewise, Agapito and Sigala (2024) revealed how IAQ management improves guest experiences. Future research should go further by designing experiments involving both staff and guests, leveraging tools like mobile apps to monitor satisfaction, physiological data and daily activities.

The framework proposed is reported in Figure 4.

Future studies can significantly contribute to theory and practice by addressing these research pathways. This will support the development of robust IAQ management strategies that enhance guest satisfaction, support sustainability goals and improve overall business performance in the hospitality industry. Integrating these research pathways with established management theories would provide a comprehensive framework for advancing IAQ management in hospitality, ensuring that both theoretical and practical insights drive improvements in guest experiences and operational practices.

Conclusion

This paper critically examined the significance of IAQ in the hospitality industry, underscoring its impact on guest health, satisfaction and overall business success. Through a comprehensive review of the existing literature and integration with management theories, the study highlights the essential role of effective IAQ management in broader environmental and sustainability practices. The findings reveal the need for advanced technological solutions and informed management strategies to improve IAQ, which would enhance guest experiences and support sustainable business practices at large.

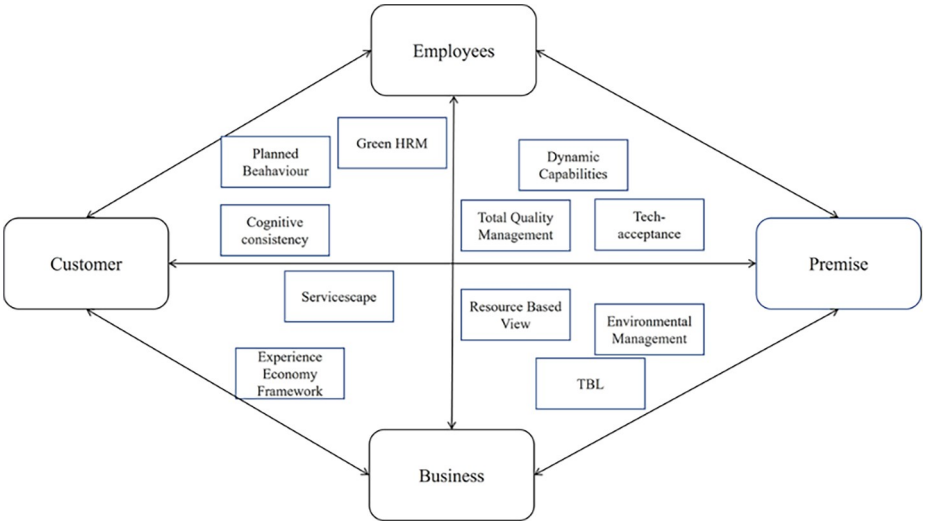


Figure 4. Framework for IAQ-related research development in the hospitality industry
Source: Authors' own work

Theoretical implications

Integrating IAQ management into hospitality practices presents a unique opportunity to contribute to and extend established management theories across premise-, employee-, customer- and business-centric dimensions.

First, drawing upon TQM (Deming, 1986) and DCT (Teece *et al.*, 1997), this research illustrates how continuous improvement and adaptive technological integration are crucial in resolving traditional tensions between maintaining optimal IAQ and achieving energy efficiency. By highlighting the value of IoT and AI-driven HVAC systems, the study advances theoretical discussions on operational excellence, sustainability management and strategic adaptability, which align with broader sustainability goals articulated by EMS and the TBL (Elkington, 1997).

Second, GHRM (Kramar, 2014) and TPB (Ajzen, 1991) offer comprehensive insights into employee-centric dimensions of IAQ management. These theories highlight the necessity of cultivating employee attitudes, providing targeted training (Chan *et al.*, 2015), and fostering an organizational culture supportive of IAQ practices. The sampled literature suggests that embedding IAQ management into organizational routines promotes proactive environmental behaviors, thereby enhancing employee well-being, satisfaction and productivity.

Third, cognitive consistency theory (Festinger, 1997) advances the importance of consistency in guest experiences, suggesting that improvements in IAQ reinforce positive guest perceptions to potentially foster enhanced loyalty and favorable word of mouth. This theory aligns closely with the experience economy framework (Joseph and Gilmore, 1998), which emphasizes the necessity of creating distinctive, memorable experiences. Consequently, maintaining high IAQ standards can become a unique selling proposition, transforming an intangible component into a competitive advantage.

Fourthly, from a business-centric perspective, the RBV (Barney, 1991) and corporate social responsibility (CSR) frameworks underscore IAQ management as a strategic resource that can lead to sustained competitive advantages. This is consistent with contemporary views of CSR in hospitality, which recognize the importance of integrating both *visible* and *invisible* environmental practices – including IAQ – into business models to meet stakeholder expectations and regulatory demands (Kuhzady *et al.*, 2025). By outlining evidence of the economic benefits (e.g. reduced energy costs, improved guest retention and strengthened reputation), this study positions IAQ management as not just a compliance measure, but as a strategic element for achieving long-term profitability and resilience.

Finally, the servicescape theory (Bitner, 1992) provides a critical foundation for understanding how both tangible and intangible environmental aspects, such as IAQ, influence guest perceptions, behaviors and overall satisfaction. By integrating IAQ within this theoretical framework, our study affirms that advanced air quality management can actively shape guests' sensory experiences to ultimately impact their satisfaction and loyalty.

Collectively, these management theories advance our understanding of IAQ's multidimensional role, effectively bridging theoretical advancements with practical strategies in hospitality management.

Practical implications

For practitioners, the paper provides actionable insights into IAQ management that can enhance guest satisfaction and operational performance. The findings suggest that investments in advanced IAQ technologies, such as smart HVAC systems and air quality

sensors, can offer dual benefits of improved guest comfort and operational efficiency, thus mitigating the eternal struggle between IAQ and energy management. The study also emphasizes the need for effective communication strategies to raise guest awareness of IAQ improvements, thereby enhancing the value they attribute to these efforts. Furthermore, the research highlights the importance of staff education and training in IAQ management, which ensures that employees are well equipped to maintain high IAQ standards.

By integrating IAQ management into hospitality practices, firms have actionable strategies to enhance guest satisfaction, employee well-being and overall business performance. From a practical perspective, IAQ improvements can differentiate hotels in a competitive market by addressing the growing consumer demand for sustainability and wellness-focused accommodations. Hospitality managers should prioritize visible and measurable IAQ efforts, such as installing advanced HVAC systems, deploying IoT-enabled sensors for real-time monitoring, and adopting sustainable building materials to reduce indoor pollutants. Transparent communication of these initiatives, such as displaying IAQ metrics in common areas or through apps, can boost guest trust and satisfaction.

To optimize IAQ monitoring and management, we recommend the following protocols:

- Regular IAQ assessments: Conduct baseline IAQ measurements during different operational scenarios, such as peak occupancy, to identify variations in air quality.
- Comprehensive pollutant tracking: Monitor key pollutants, including PM2.5, PM10, carbon dioxide, VOCs and humidity levels, in high-impact areas like guest rooms, lobbies and dining spaces.
- Continuous monitoring: Use IoT-based air quality sensors to provide real-time data and enable immediate responses to IAQ fluctuations.
- Data integration and reporting: Use centralized dashboards to merge IAQ data with operational metrics, allowing for streamlined decision-making and compliance reporting.
- Preventive maintenance protocols: Schedule regular maintenance of HVAC systems, air purifiers and filtration systems to ensure optimal functionality.
- Staff training: Educate employees on IAQ best practices, including proper cleaning methods and the safe use of cleaning agents to minimize pollutant levels.
- Stakeholder engagement: Better frame the IAQ monitoring and management effort and integrate the results into the broader approach toward sustainability strategy and reporting.

Practically, IAQ management also supports employee well-being by reducing exposure to harmful pollutants. This, in turn, enhances job satisfaction, productivity and retention rates. Hotels can further strengthen these outcomes by aligning IAQ initiatives with Green HRM practices, such as providing protective measures and promoting employee participation in sustainability programs.

For businesses, demonstrating a commitment to high IAQ standards can enhance brand reputation and attract environmentally conscious guests. By harmonizing IAQ protocols into broader sustainability strategies and effectively communicating these efforts through marketing channels, hotels can solidify their position as leaders in sustainable hospitality. In addition, conducting cost-benefit analyses that link IAQ improvements to energy savings and guest retention rates can support a robust business case for continued investments in IAQ management. These efforts would not only ensure regulatory compliance, but also drive long-term profitability and resilience in the hospitality industry.

Limitations and future research

This study contains some inherent limitations. First, the research relies on a semi-systematic literature review, potentially limiting the generalizability of the findings due to the selective nature of literature sampling and analysis. Moreover, while the semi-systematic approach ensured a comprehensive exploration of relevant literature, it might have inadvertently overlooked pertinent contributions due to database selection criteria and search string limitations. Future research may consult with experts in the hospitality field to glean a broader set of selection criteria or include grey literature in the review to capture updated practical insights.

In addition, the theoretical framework and practical insights proposed have yet to be empirically validated through primary data collection. Ideally, scholars would pursue a multiple case-study approach that can consider different socioeconomic contexts and geographical areas, as well as different hospitality contexts and modes. Finally, our research underlines the need for longitudinal and cross-cultural studies: Current insights might not fully account for temporal changes or cultural variations that impact IAQ perceptions and outcomes within hospitality contexts.

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Supplementary material

The supplementary material for this article can be found online.

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