

Systematic Review

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# New Health and Safety Technologies in Hotel Restaurants in Response to the COVID-19 Pandemic: A Systematic Review <sup>+</sup>

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- <sup>+</sup> This article is a revised and expanded version of a paper entitled [New Technologies In Health And Safety In Hotel Restaurants During COVID-19: A Systematic Review], which was presented at [Recent Advancements in Tourism Business, Technology and Social Sciences—10th International Conference, IACuDiT, Crete, Greece, 29–31 August 2023]. First published in Springer Proceedings in Business and Economics by Springer Nature.

Abstract: The end of the pandemic has been officially declared; however, the requirement to ensure hygienic living conditions in tourist accommodations remains a top priority for all hotel establishments and a prerequisite for every customer. Our systematic review studied the level of effectiveness of existing technological means and practices in order to limit COVID-19 infections and to protect customers from other factors aggravating their health, focusing on hotel restaurants. The PRISMA-S method was used. Database research (ABI/INFORM, ProQuest, Scopus EBSCO Business Source Premier, CBCA Business, Pubmed, and Embase) was undertaken between 6/2020 and 4/2024 with keywords comprising "hotels restaurants", "health and safety", "effectiveness/efficacy", "primary analysis", secondary analysis", etc. In total, 1110 articles were initially identified, but eventually, 20 papers were selected comprising customer-level questionnaires, systematic reviews, and expert opinions/surveys. Different criteria were used for study assessment according to the type of study. So far, only a very limited number of studies have focused on the effectiveness of different health and safety measures in hotel restaurants. Even though the studies focusing on AI, robotics, and further technological means for enhancing customer satisfaction and the overall level of cleanliness are quite limited, the constant investment of hotels and restaurants in new technologies appears to be a one-way road.

Keywords: hygiene; safety; technology; hotel restaurants; systematic review

# 1. Introduction

The COVID-19 pandemic has taken an immense toll on the hospitality industry. In the US, 41.3% of businesses were closed due to the pandemic, with the restaurant industry suffering a huge impact from the restriction measures and lockdowns. According to the National Restaurant Association, it is estimated that restaurants had lost \$240 billion in revenue by the end of 2020 (National Restaurant Association, 2021). In the US, five million jobs were lost in April only in the restaurant industry, which contributed to one-fourth of the country's total job loss (Wei et al., 2021). At the beginning of the pandemic, extremely strict health measures were introduced regarding public protection and also for the maintenance of a healthy professional environment. After the pandemic, the requirement to ensure hygienic living conditions remained crucial in tourist accommodations, since it is a top priority of customer preference and booking intention. Specifically, the level of cleanliness and hygiene were, and are even more so after the pandemic, decisive factors when choosing and using an accommodation (Pillai et al., 2021).



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Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/ licenses/by/4.0/). In order to achieve the expected levels of safety protocols and enhance cleanliness in indoor and outdoor facilities, new technologies such as artificial intelligence including service robots, ventilation systems, and self-service technologies, have been embraced by the hospitality and catering industry. Through their implementation, tourist accommodations and restaurants hope to improve customer's perception of health and safety measures and enhance booking intention as well as revisit intention (Pillai et al., 2021; Roussakou & Carayanni, 2024; Vandenhaute et al., 2022). Besides cleanliness, various studies have highlighted other substantial factors that show the importance of integrating service robots in hotels. To begin with, new technological advancements can have an influence on consumers' expectations of novel experiences and also the connection to showing off their experience to others through social media. The overall usefulness and ease of use of robots have also been noted, even though the specific parameters appear to be affected by variables like age and culture (Kim et al., 2021).

When thinking about the extreme social and traveling changes that the COVID-19 pandemic introduced, implementing AI and robots can help provide better hygiene conditions for both customers and staff (Shin & Kang, 2020). Indeed, it has been found that technology innovation (such as robots) is important in consumer decisions and considered essential in reducing perceived health risks regarding expected levels of interaction in hotels. It is believed that travelers' current perception of health and safety will have been highly influenced by the pandemic of COVID-19 and thus possibly lead to a gradually greater preference for robot-staffed hotels, since they are perceived as facilitators in decreasing exposure to the virus (Kim et al., 2021).

The end of the COVID-19 pandemic as a Public Health Emergency was declared by the WHO on 5 May 2023 (Chang et al., 2021). However, people around the world appear to still worry about their safety in public transport, public services, closed buildings, and also hotels and restaurants. Therefore, the need for efficient technological means and practices that can be adopted by the Hotel and Restaurant industry in order to limit COVID-19 infections and to also protect customers from other factors endangering their health is more crucial than ever (Nahavandi, 2019; Roussakou & Carayanni, 2024).

In this article, a systematic review regarding the integration and effectiveness of new technological means and practices in order to limit COVID-19 infections was conducted. The main purpose of our review was to check the level of customers' and employees' health protection in tourist accommodations, with an emphasis on hotel restaurants, from factors aggravating their health through the integration of new strategies, focusing primarily on AI and robot technologies.

#### Theoretical Background

Different technologies that enhance the level of cleanliness are now available for the hospitality industry to integrate in the post-COVID-19 era. The pandemic became the main cause of businesses having to immediately implement various and mostly electronic service modifications, such as contactless delivery, QR codes instead of actual printed catalogs, and onsite mitigation strategies, such as mask mandates and physical distancing, in order to enhance the level of safety for the customers (Pillai et al., 2021; Roussakou & Carayanni, 2024).

In the new hospitality era, there appear to be three systems that facilitate this integration of technologies. The human–cyber–physical system (HCPS), the internet of things (IoT), and the internet of service (IoS) (Pillai et al., 2021). An HCPS is usually characterized by a large number of sensors. Multiple sensory devices such as touch screens, light sensors, and force sensors are broadly used in HCPSs. Through HCPSs, maximum benefits from human as well as machine intelligence are gained, which facilitates customer service and satisfaction parameters. In fact, the latest information regarding technology integration into HCPSs provides valuable information in order to help reduce the health risks created by COVID-19 through contactless service (Pillai et al., 2021).

It has been noted that we are currently undergoing the Fifth Industrial Revolution, which uses all of the above systems in order to create a new working environment that will be characterized by closer cooperation between man and machine. (Nahavandi, 2019; Pillai et al., 2021).

Regarding the hospitality and catering industry, the involvement of HCPSs is expected to lead to improved food safety through the integration of sensors that can scan for diseases and also assess the freshness and hygiene level of products. Moreover, recent breakthroughs in technologies collectively integrated into HCPSs promise to reduce health risks created by COVID-19 through contactless service (Pillai et al., 2021).

In the field of IoT systems, the hospitality industry can make great use of the specific system by using phone-enabled lighting, motorized drapes, smart thermostats, and door lock sensors with "Do Not Disturb" features in various guestrooms (Nadkarni et al., 2019).

Finally, the IoS is a new way of systematically using the internet for value creation in the services sector (Terzidis et al., 2012). In the hospitality industry, the IoS can be used to connect the IoT to guest services and analyze information about guest preferences, customer billing, spa services, restaurant services, and room availability. During the COVID-19 pandemic, various health and safety techniques were implemented by the restaurant industry in order to minimize social distancing and to decrease the spread of COVID-19. Using QR codes instead of actual catalogs and also single-use service items are some of the most representative measures. (Xu et al., 2022; Roussakou & Carayanni, 2024).

When looking at factors that appear to facilitate the transmission of COVID-19, one of the most important threats that the hospitality and catering industry must protect customers from is the presence of particulate matter (PM). Specifically, micron-sized particles are considered a cause of acute and chronic respiratory illnesses. Considering the spread mechanism of SARS-CoV-2, it is highly recommended that restaurants implement hygiene measures that include cleaning, sanitization, disinfection, and, most importantly, ventilation mechanisms (Chang et al., 2021; Roussakou & Carayanni, 2024).

According to scientific data, cooking fumes are considered to be a significant source of indoor particulate matter (PM) pollution that can affect human health in both home and professional kitchens. PM has been linked to health problems that vary from acute or chronic respiratory diseases to lung cancer (Chang et al., 2021; Roussakou & Carayanni, 2024).

Through studies, it has become evident that even short-term exposure to PM pollution may lead to an increase in possible viral infection. Since COVID-19 is a severe respiratory illness, PM could be a facilitator in the virus's ability to spread and also affect more individuals. Fisher et al. (2020) have demonstrated that a higher number of confirmed COVID-19 cases in the US was observed among individuals who patronized restaurants than among those who did not (Chang et al., 2021; Fisher et al., 2020; Roussakou & Carayanni, 2024).

The filtering of incoming air through air decontamination devices is considered crucial to minimize such possible infections. Specifically, in the study of Zhao et al. (2019) the main conclusion evidences the above claim. Although, the specific study was not in the field of the hotel and restaurant industry related to the COVID-19 pandemic but regarded the 2015 outbreak of the pathogenic avian influenza (HPAI) H5N2 in the US, especially the severe consequences on its poultry industry. In their results, the authors emphasize the importance of applying strategies such as the fast depopulation of the infected poultry flocks and the filtration of incoming air (Zhao et al., 2019; Roussakou & Carayanni, 2024).

Through the study, the final conclusion drawn was that indoor air decontamination could be a very efficient measure to decrease infection risk. (Zhao et al., 2019).

When considering new and enhanced hygiene protocols that can be applied in the tourism and restaurant industry, robots can be used in providing necessary services to guests in the hospitality industry. A robot can serve as a substitute for humans in certain cases of controlling virus infections. A robot called a Social Distancing Robot Ambassador is a three-foot robot for delivering pillows and groceries. For example, a few of them are used at renowned hotels, such as Winnie (Embassy Suites by Hilton Los Angeles International Airport North), Wally (Residence Inn by Marriott Los Angeles LAX/Century Blvd), and Hannah (H Hotel Los Angeles, Curio Collection by Hilton, Homewood Suites by Hilton Los Angeles International Airport).

Furthermore, virus assassination robots, through the use of ultraviolet light, are now available for implementation. The purpose of virus assassination robots is to maintain hygiene and kill viruses and germs. UVD robots from Blue Ocean Robotics use ultraviolet light to autonomously kill bacteria and viruses (Alotaibi & Khan, 2022; Roussakou & Carayanni, 2024).

The specific robots were found to be highly effective in China during the COVID-19 pandemic for routine or non-routine tasks. Ultraviolet (UV) light was used for surface disinfection in order to limit potential virus contamination (Pillai et al., 2021).

The new Industrial Revolution in the hospitality sector integrates AI, robots, automation, VR/AR, and mobile technology. These measures can play a major role in enabling hygiene, cleanliness, and safety, particularly in high-touch areas during pandemic and post-pandemic periods (Pillai et al., 2021).

# 2. Materials and Methods

The PRISMA method was used, primarily because it is an important guideline to assist researchers in further improving the transparency of reporting systematic review and meta-analysis results (Selcuk, 2019). Relevant AI and robotics-related articles in restaurants and tourism were collected starting from June 2020 with both authors participating in the data collection process. A consensus was reached for search keywords and criteria after discussion among the authors. Both authors would read the titles and abstracts of the displayed publications in order to determine the relevance of the articles. Databases research included ABI/INFORM, ProQuest, Scopus EBSCO Business Source Premier, CBCA Business, Pubmed, and Embase). All the databases were used in combination with Google Scholar in order to identify additional research articles.

The timeframe of our research was between 6/2020 and 4/2024 and the search strategy included the keywords "hotels restaurants", "health and safety", "effectiveness/efficacy", "primary analysis", "customer satisfaction", "consumers satisfaction", "secondary analysis", "robots", "new technologies", and "hotel restaurants".

In our systematic review, primary and secondary studies were included, such as crosssectional and longitudinal studies, expert opinion studies, database research, systematic reviews, and meta-analyses in the field of new technologies in hotel restaurants. Inclusion criteria were that the study must have compared new health and safety technologies; were either experimental, observational, or secondary research (meta-analyses, systematic reviews); and were published in the timeframe from 6/2020 to 4/2024. Editorial opinion articles, letters to the editor, and narrative reviews without any quantitative data were excluded from our study. Overall, 20 studies were eventually included.

For the quality assessment of these studies, we applied the standard quality assessment criteria (SQAC) for evaluating primary research papers established by Kmet et al. (Kmet et al., 2004), AMSTAR-2 criteria for systematic reviews (Lu et al., 2020), and the criteria of Nasa et al. (Nasa et al., 2021) for Delphi studies.

# 3. Results

## 3.1. Selection of Studies and PRISMA Flowchart

Figure 1 indicates the PRISMA 2020 flow diagram for new systematic reviews. As can be seen, only 20 studies were eligible according to our criteria. After the elimination of 300 duplicates, the review of 810 articles led to the additional elimination of 762 studies, initially identified as they were narrative reviews, editorials, statements, and letters and did not meet our inclusion criteria.



Figure 1. PRISMA flow chart.

#### **Figures and Tables**

As can be seen in Table 1 and Figure 2a, the majority of the studies are primary research using as a statistical unit the consumers (hotel/restaurant customers), and the technology most broadly studied is robots. The design of these studies is cross-sectional and one study is a case study (Chang et al., 2021). One study uses expert elicitation by the Delphi method (Buhalis & Moldavska, 2022). Six studies are secondary research using databases to collect their data and three studies are systematic reviews (Davahli et al., 2020; Duval et al., 2022; Elkhwesky et al., 2024). One study comprises both primary and secondary research (Lein et al., 2023).



**Figure 2.** (a) % distribution of studies according to the type of research; (b) evaluation of consumer-level studies according to SQAC (Standard Quality Assessment Criteria). (Roussakou & Carayanni, 2024).

Table 1. Brief description of the studies selected.

Authors, Year	Title	Research Type	Technologies Studied
(Romero & Lado, 2021)	Service robots and COVID-19: exploring perceptions of prevention efficacy at hotels in generation Z	Primary research (Customer Sample)	Robots
(Lein et al., 2023)	Using a Social Robot as a Hotel Assessment Tool.	Primary Research (Customer Sample) + Secondary Research (Social Media)	Social Robots
(Kim et al., 2021)	Preference for robot service or human service in hotels? Impacts of the COVID-19 pandemic	Primary Research (Customer Sample)	Robots
(Nozawa et al., 2022)	Consumer responses to the use of artificial intelligence in luxury and non-luxury restaurants	Primary Research (Customer Sample)	Service Robots
(Buhalis & Moldavska, 2022)	Voice assistants in hospitality: using artificial intelligence for customer service.	Primary Research (Expert Opinion)	Voice Assistants
(Seo & Lee, 2021)	The emergence of service robots at restaurants: Integrating trust, perceived risk, and satisfaction	Primary Research (Customer Sample)	Service Robots
(Xu et al., 2022)	Consumers' perceived effectiveness of COVID-19 mitigation strategies in restaurants: What went well and what could we do better?	Primary Research (Customer Sample)	Robots, Ventilation Systems, Cleaning Strategies, Self-Service Technologies
(Guan et al., 2022)	Exploring key factors influencing customer behavioral intention in robot restaurants.	Primary Research (Customer Sample)	Restaurant Robots

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Authors, Year	Title	Research Type	Technologies Studied
(Sharma et al., 2021)	Hotels' COVID-19 innovation and performance	Secondary Research (Hotels' Published Data)	Self-Service Kiosk, Check-In Machines, Cleaning Robots, Electrostatic Sprayers
(Hsieh et al., 2021)	Government and social trust vs. hotel response efficacy: A protection motivation perspective on hotel stay intention during the COVID-19 pandemic	Primary Research (Customer Sample)	New Cleaning Protocols
(Duval et al., 2022)	Long distance airborne transmission of SARS-CoV-2: rapid systematic review	Secondary Research (Systematic Review)	Ventilation Systems
(Chang et al., 2021)	Why cleaning the invisible in restaurants is important during COVID-19: A case study of indoor air quality of an open-kitchen restaurant	Primary Research (Case Study with Consumer-Level Data)	Kitchen Ventilation Systems
(Ye et al., 2022)	A Review of Robotic Applications in hospitality and Tourism Research	Secondary Research (Consumer Database)	Robotic Applications
(Pillai et al., 2021)	COVID-19 and hospitality 5.0: Redefining hospitality operations	Secondary Research (Conceptual Study)	Robots
(Wei et al., 2021)	COVID-19 preventive measures and restaurant customers' intention to dine out: the role of brand trust and perceived risk	Primary Research (Customer Sample)	COVID-19 Perceived Preventive Measures and Brand Trust on the Intention to Dine Out at Restaurants
(Vandenhaute et al., 2022)	COVID-19 Safety Measures in the Food Service Sector: Consumers' Attitudes and Transparency Perceptions at Three Different Stages of the Pandemic	Primary Research (Consumer and Businesses Sample)	Consumers' Attitudes Towards and Transparency Perceptions of COVID-19-Related Safety Measures
(Elkhwesky et al., 2024)	Driving hospitality and tourism to foster sustainable innovation: A systematic review of COVID-19-related studies and practical implications in the digital era	Secondary Research (Systematic Review)	Sustainable Innovation—AI
(Arica et al., 2023)	Examining reviews on hotels' measures about COVID-19 from a value cocreation and value codestruction perspective	Primary Research (Customer Sample, Reviews)	Pandemic Measures and Robots

Table 1. Cont.

Authors, Year	Title	Research Type	Technologies Studied
(Shin & Kang, 2020)	Reducing perceived health risk to attract hotel customers in the COVID-19 pandemic era: Focused on technology innovation for social distancing and cleanliness	Primary Research (Consumer Sample)	Robots
(Davahli et al., 2020)	The hospitality industry in the Face of the COVID-19 Pandemic: Current Topics and Research Methods	Secondary Research (Systematic Review)	A.I.

#### Table 1. Cont.

#### 3.2. Studies Results Presentation

Through a screening of the studies, the most significant results, according to our main research question, are presented below. In order to form a more coherent text, we decided to create categories of results regarding the connection between new technologies, AI, and robots with parameters like effectiveness against COVID-19 transmission, hotel and restaurant ratings, booking intention, brand trust and overall satisfaction, and the behavior of customers towards technological innovations.

3.2.1. During Pandemic Times, Customers' Acceptance of New Technologies That Enhance Touchless Services Appears to Increase; Additionally, Service Robots Are Presented as Facilitators in the Reduction in Infection Risk and Have an Important Impact on Business Recovery from COVID-19

A very important conclusion, evident in almost all of the studies that we screened, was the connection between robots and the enhancement of booking intention, the overall improvement in customers' tourist dine-out experience, and the application of enhanced hygiene measures that are mandatory during pandemic times.

To begin with, Ye et al. (2022) analyzed the positive consequences of robotic adoption in the tourism sector. This study reviewed 86 articles regarding robotic applications in the sector of hospitality. Ye et al. (2022) studied articles regarding research mostly carried out in hotels. Specifically, only 25 of the studies reviewed were conducted in the restaurant sector and only 3 of the studies were conducted in both hotels and restaurants. In total, 13 articles were included in the mixed context. A very important conclusion derived from one of the studies was that health-related crises connected to cleanliness levels and virus transmission like the pandemic of COVID-19 appear to enhance the level of acceptance detected among customers towards the use of robotic servers. Overall, the researchers concluded that hotel service robots appeared to have a positive effect on the booking intention of customers and the total travel experience (Ye et al., 2022).

Additionally, Romero and Lado (2021) studied the application of service robots in hotels, focusing on Generation Z individuals as a sample. Their hypotheses combined an experimental design methodology with partial least squares. The researchers collected data from 711 Generation Z individuals in Spain in two periods of time. As mentioned in the study, robots and other automation technologies are advantageous tools in order to enhance social distancing. It is also noted that robots will have a major role in restoring customer confidence and enhancing business recovery after the pandemic.

The specific study examined multiple hypotheses about service robots. All hypotheses regarding robots, efficacy, and perceived susceptibility were supported. Specifically, it was found that perceived susceptibility is positively associated with robot efficacy in preventing COVID-19 for Generation Z individuals (*p*-value < 0.01). That is, it was concluded

through participant data that if customers perceive that robots can reduce the COVID-19 contagion risk, they will develop positive attitudes towards being attended by a robot (*p*-value < 0.01). Finally, attitudes towards being attended by a robot in hospitality contexts appeared to positively affect booking intention in Generation Z participants (*p*-value < 0.01) (Romero & Lado, 2021).

Furthermore, in the study of Kim et al. (2021) that included 134 adults as a sample, one of the hypotheses regarded that in the COVID-19 pandemic situation, the preference for a robot-staffed (vs. human-staffed) hotel will be higher when the risk of COVID-19 is high (vs. low). Indeed, the findings supported this view. Particularly in the context of a health crisis, customers' preference for robot services appears to increase since the deployment of service robots can help reduce the chance of disease transmission. Another important conclusion was that a particular event or crisis, like the pandemic, can change customers' mindsets and attitudes towards new technology, especially in the field of robot services acceptance. The study of Kim et al. (2021) appears to bear similar conclusions regarding the connection between robots and the COVID-19 pandemic when compared to results from Ye et al. (2022) and also Romero and Lado (2021) (Kim et al., 2021; Romero & Lado, 2021; Ye et al., 2022).

Moreover, Buhalis and Moldavska (2022) studied the inclusion of voice assistants (VAs) in hospitality. As concluded by the findings, during the COVID-19 period, touchless services became favorable for travelers as they were safer to use. Contactless devices, including VAs, offer boundaryless interactions. As it is also highlighted, the physical aspect of increased hygiene became paramount in the COVID-19 era. The integration of new technology can lower the barrier of interactions with hotels for those guests who normally would be reticent to communicate with staff. Once again, the increasingly new positive perception of customers towards the integration of new technology, AI, and robots is evident due to the demand to maintain high levels of hygiene and social distancing during pandemic times (Buhalis & Moldavska, 2022).

In the study of Xu et al. (2022) researchers focused on consumers' perceived effectiveness of the COVID-19 mitigation strategies applied in restaurants. Through the use of a scale, consumer's opinions on the effectiveness of strategies regarding health and hygiene, safety measures for customers, and other parameters were studied. "Health and hygiene" strategies were considered of high importance. Respondents were satisfied with restaurants' current executions of these practices in the area of employee safety measures, as well as health and hygiene. Therefore, restaurants should continue to perform well in these areas, such as rigorous disinfection practices and COVID-19 transmission mitigation measures for staff and customers. The results also revealed that restaurants should continue to reinforce training for food safety and sanitation and employee hygiene. Though in the specific study, the integration of AI and robots is not thoroughly presented, the connection with new restaurant hygiene strategies for minimizing COVID-19 transmission is indisputable. Therefore, through our systematic review, it appears that five studies already provide extremely valuable insight into the value of the constant inclusion of new technologies in the hospitality and restaurant sector (Buhalis & Moldavska, 2022; Kim et al., 2021; Romero & Lado, 2021; Xu et al., 2022; Ye et al., 2022).

3.2.2. Long-Distance Airborne Transmission of SARS-CoV-2 in Indoor Community Settings Can Be Mitigated Through the Enhancement of Ventilation Systems

Additionally, Xu et al. (2022) highlighted the value of the information provided in the article of Chang et al. (2021) that demonstrated the importance of restaurants' cleaner indoor air quality in the mitigation of COVID-19 and highly recommended that restaurants should try to enhance their ventilation systems as part of new health protocols and health strategies (Chang et al., 2021; Xu et al., 2022).

In a similar vein, the systematic review of Duval et al. (2022) studied the potential for the long-distance airborne transmission of SARS-CoV-2 in indoor community settings, as well as factors that might influence transmission. This rapid systematic review found evidence suggesting that the long-distance airborne transmission of SARS-CoV-2 might occur in indoor settings including restaurants, workplaces, and venues for choirs. A major factor that was identified as a possible facilitator for the transmission was insufficient air replacement, which probably contributed to transmission. This conclusion agrees with the results from Xu et al. (2022) and especially Chang et al. (2021) that highlight the need for the immediate integration of indoor air ventilation systems in hotels and restaurants (Chang et al., 2021; Duval et al., 2022; Xu et al., 2022).

Evidence from the outbreak investigations presented in this systematic review suggested that the airborne transmission of SARS-CoV-2 from an infectious individual to others located more than 2 m away can occur in different indoor nonhealthcare spaces. Insufficient air replacement was detected as a parameter that is likely to enhance the concentration levels of infectious respiratory particles in indoor facilities. Additionally, researchers note that directional airflow is another factor that may enhance a viable virus's ability to travel a greater distance in a certain direction, ultimately leading to a greater potential for infecting different individuals. Therefore, the final conclusion from the specific systematic review further highlights the need for businesses like restaurants and hotels to further invest in enhanced ventilation systems in order to help mitigate the risk of long-distance aerosol transmission (Duval et al., 2022).

# 3.2.3. Different Parameters Can Affect Customers' Behavior Towards the Integration of New Technology, AI, and Robots in Hotels and Restaurants

As noted above, the pandemic of COVID-19 has appeared to increase customers' acceptance of touchless services and, most importantly, robots. Enhanced hygiene measures and the effectiveness in the reduction in infection risk are major parameters that facilitate the acceptance of new technology in the hotel and restaurant industries (Buhalis & Moldavska, 2022; Kim et al., 2021; Romero & Lado, 2021; Ye et al., 2022).

In the study of Seo and Lee (2021), the factors that are involved in consumer behavior towards robot integration in restaurants were studied, specifically trust, perceived risk, and satisfaction. The methodology involved the Technology Acceptance Model's (TAM) original constructs, which included perceived usefulness, perceived ease of use, and acceptance, in restaurant settings that are characterized by robot integration. A scenario-based online survey was performed on, overall, 338 participants. Data were collected through the utilization of a web-based survey platform. The target population included restaurant consumers in Korea. Structural equational modeling showed the direct impact of perceived usefulness (PU) and the indirect impact of perceived ease of use (PEOU) on consumers' revisit intention to robot restaurants. According to the results, PU and PEOU towards a service robot appeared to significantly increase through trust, and increased trust in robot service seemed to decrease the perceived risk while increasing satisfaction. There was a significant effect of perceived usefulness on behavioral intention (b = 0.616; t = 6.788; p < 0.001). Perceived ease of use had no significant effect on behavioral intention (b = 0.002; t = 0.021; p > 0.05) (Seo & Lee, 2021).

Additionally, Guan et al. (2022) explored the impact of the robot restaurant servicescape and robot service competence (RSC) on customers' behavioral intentions and analyzed the mediating role of hedonic value (HV) and utilitarian value (UV) in these relationships and the moderating role of individual characteristics. The sample consisted of Foodom robot restaurants, located in Shunde and Guangzhou in China. A total of 485 valid data was collected. Researchers highlighted that, due to the COVID-19 pandemic, which increased the need for contactless services, the introduction of new services, such as intelli-

gent reception, unmanned retail, and unmanned distribution in the tourism and catering industry can not only effectively reduce the level of the risk of cross-infection between people but also provide the basis for the popularization of service robots (Guan et al., 2022).

Eventually, through structural equation modeling analysis, it was found that the servicescape of the robot restaurant and the service competence of robots significantly affected the behavioral intentions of customers (Guan et al., 2022).

However, regarding the integration of AI in restaurants, in the study of Nozawa et al. (2022), the results obtained did not provide a positive view of customers towards the specific technology. Data obtained from 101 Japanese participants who completed a survey on a possible promising future when it comes to adopting AI chefs in restaurants provide us with the information that new technology integration is not always seen as beneficial. The study examined participants' opinions on luxury and non-luxury restaurants. Participants had to answer how desirable they considered the products and services made by AI compared to humans. The results supported the researcher's predictions; that is, desirability appeared to be lower for products and services provided by AI than humans (H1), which also appeared to be more prominent in the context of luxury (H2) (Nozawa et al., 2022).

3.2.4. Technological Innovations for Reducing COVID-19 Infection Risk Appear to Affect Guest Confidence, Stay Intention, Positive Ratings Given to Hotels from Customers, and Overall Hotel Market Value—Brand Trust

In the midst of a pandemic, it is beyond dispute that the main strategy for hotels in order to attract customers is to increase the level of safety measures. As stated by Sharma et al. (2021), product–process innovation for enhancing the level of safety is expected to have a much greater impact on customers when compared to organizational and marketing innovations (Sharma et al., 2021).

In the study of Sharma et al. (2021), it was concluded that COVID-19-related innovations on all three levels (product–process, organizational, and marketing) appear to have a positive influence on shareholder perception, which ultimately leads to an enhancement in a hotel's market value. Strategies focused on innovations are perceived as reducing hotel guests' and staff's exposure to risk, and a very important outcome is the contribution to fostering a safer and healthier environment, which is the main goal during pandemic times (Sharma et al., 2021; Shin & Kang, 2020).

Very interesting information from Sharma et al. (2021) notes that in the study of Shin and Kang (2020), it was concluded that a hotel's gradual application of innovations, employed for maximizing social distancing, reducing guest interactions, and improving the overall hygiene level of the infrastructure have a positive impact on customers' booking intention (Sharma et al., 2021; Shin & Kang, 2020).

Sharma et al. (2021) also conclude that innovations implemented by hotels are perceived to be efficient and could facilitate an increase in confidence in the ability of hotels to create a safe environment. However, not all innovations that have been deployed have a similar effect. Regarding the importance of the category of innovations, it is evident that innovations focused on safe service delivery like enhanced cleaning procedures and social distancing are more significant than organizational and marketing innovations that mainly focus on managerial actions during the pandemic. This result is in line with the finding of Shin and Kang (2020), that technology product innovations are effective in reducing health risks perceived by consumers, resulting in higher hotel booking intention, and also results from the previous studies included in our systematic review (Sharma et al., 2021; Shin & Kang, 2020).

In the study of Shin and Kang (2020), the purpose was to examine the impact of expected interaction and expected cleanliness on perceived health risks and hotel booking intention. The research focused on technology innovation for reducing guest interaction

with employees and enhancing cleanliness levels. The main focus was on guest checkin and housekeeping systems, regarding their possible impact on social distancing and customer interactions. One of the hypotheses included that expected interactions with personnel would affect the level of health risk that customers perceive. Specifically, lower levels of health risk would be considered by guests when they are informed that technologybased services, such as mobile check-in systems and robot cleaning services, have been integrated into the hotel (Shin & Kang, 2020).

As concluded by the study, a significant effect of expected interaction on perceived health risk was found regarding robot cleaning (M = 3.88, SD = 1.27) and housekeeping employee cleaning (M = 4.73, SD = 1.56); F(1, 156) = 16.94, p < 0.01 (Shin & Kang, 2020).

Similarly, Hsieh et al.'s (2021) study was based on protection motivation theory (PMT), and its main topic was to study customer booking intentions in hotels during the COVID-19 pandemic. The sample consisted of 700 US consumers and data were collected via a crowdsourcing website. Structural equation modeling was utilized for the analysis. A well-expected result was that the level of threat perceived by customers led to a significant reduction in their intention to book a stay at a hotel. Contrarily, individual customer response efficacy significantly increased their desire to stay at a hotel. Government and social trust, as well as hotel response efficacy, were also recognized as parameters that can significantly increase booking intention. (Hsieh et al., 2021).

Individual customer response efficacy, within Hsieh et al.'s (2021) research context, regards the degree to which individuals believe that applying global health measures against COVID-19 like masks, social distancing, and washing hands can effectively minimize the possibility of COVID-19 transmission and risk. The hypothesis that perceived government and social trust would be positively related to the intention to stay in a hotel was supported. Moreover, a positive relationship between hotel response efficacy and intention to stay in a hotel was also observed. Regarding new technologies, like AI and robots, in the enhancement of these intentions, the specific study did not thoroughly include the examination of the above technologies. However, as mentioned in the study, when it comes to enhanced hygiene measures that are applied by hotels, these included methods like contactless check-in and check-out with digital keys and several applications of new cleaning technologies (Hsieh et al., 2021).

Wei et al.'s (2021) study was conducted in the restaurant environment and examined the roles of perceived preventive measures and brand trust on the intention of customers to dine out at restaurants during the reopening period of the pandemic in the United States. The sample consisted of 587 participants who were recruited through a market research company. Data analysis provided evidence that the perceived importance of preventive measures enhanced customers' intention to dine out via brand trust. Perceived risk moderated the relationship between the perceived importance of preventive measures and brand trust.

Though the study did not include information about the integration of AI and robots, the results obtained provide valuable insight since through the data analysis it was supported that preventive measures related positively to customers' restaurant brand trust (0.3031, p < 0.01). Moreover, the analysis demonstrated that the indirect effect of preventive measures on intention to dine out via brand trust was significant. Therefore, the effect of the perceived importance of preventive measures on restaurant customers' intention to dine out was fully mediated by brand trust towards the restaurant. Additionally, these results also suggested that there is a need for restaurants to seek strategies to increase customers' willingness to dine out (Wei et al., 2021).

Furthermore, Vandenhaute et al. (2022) examined consumers' attitudes and transparency perceptions of COVID-19-related safety measures and tried to detect the determinants of consumers' intentions and behavior regarding visiting restaurants and bars during the reopening periods after the pandemic. The sample consisted of 1697 consumers and 780 businesses and was conducted in Belgium both during and in between waves of infections. As the authors initially mentioned, through the analysis of the existing literature, consumers seem to favor restaurants that use partitions to enhance social distancing. Once again, cleanliness (environmental and also regarding customers' perceptions) has risen significantly since the COVID-19 outbreak. Eventually, perceived restaurant cleanliness appears to have a positive impact on customers' satisfaction, which similarly positively impacts revisit intention (Vandenhaute et al., 2022).

The results indicated that, regardless of the general concern that was evident to all consumers about safety measures, the attitudes towards the measures could be classified as categories regarding hygiene, avoidance of object sharing, and organization. To begin with, hygiene measures, focusing on the disinfection of hands and also the disinfection of surfaces, are considered highly important. This points to the high level of value consumers consider disinfecting to have regarding the prevention of virus transmission while consuming food out-of-home. The results demonstrated that consumers evaluated safety measures as important when revisiting restaurants and bars, against business owners' expectations. One of the final conclusions derived was that both consumers' revisit intentions and behaviors appear to be influenced by the perceived importance of hygiene measures (negatively) and past visit frequency (positively) (Vandenhaute et al., 2022).

Finally, ratings are a major part of the brand of each hotel and restaurant, since the level of satisfaction from different customers is reflected in them. In the study of Arica et al. (2023), posts that tourists accommodated in hotels located in Alanya, Turkey during the COVID-19 pandemic shared on the TripAdvisor website regarding the pandemic measures taken by the hotel were analyzed within the context of value cocreation and codestruction. The study aimed to evaluate the effects of posts made by tourists on scores they would give to the hotel, whether they perceived the hotel as safe, recommendations, and also revisit intention. Overall, 1119 reviews on TripAdvisor about 109 hotel establishments in Alanya were examined. SPSS program coding was utilized with separate binary coding for positive and negative situations. As noted by the researchers, when perceived positively by tourists, general measures applied in order to minimize the risk of virus transmission during the pandemic seem to have a significant and positive effect on the score given to the establishment ( $\beta$  5 0.305; *p* < 0.001); however, they are seen to have a much greater negative effect on hotel score when there is the perception that general measures are not followed ( $\beta$  5 \_1.044; p < 0.001). The results highlight the importance that hotels should constantly try strengthening their measures in order to enhance positive customer perception of safety measures that will lead to an increase in hotels' positive scores (Arica et al., 2023).

As also concluded by Arica et al. (2023), the COVID-19 outbreak could definitely be considered the starting point for the acceleration of the implementation of AI and the use of robotics in the tourism sector. The use of the above in hotel establishments will surely help to achieve the cleaning, hygiene, and social distancing requirements that the pandemic has introduced and that the management of any future pandemics will require (Arica et al., 2023).

Finally, in the study of Lein et al. (2023), the influence of social robots as a hotel assessment tool on hotel ratings was investigated. Based on media equation theory, researchers studied whether social robots could enhance the quality and quantity of hotel ratings by triggering politeness rules. The authors developed a robot application that hotel guests could use in order to provide ratings on-site together with the robot Pepper. Data from robot interactions were compared with data from TrustYou (an online rating platform). The results showed the potential of social robots as an assessment tool with a trend towards a

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better overall rating when evaluating a hotel by using a robot rather than a website. The results provided evidence that a robot can be considered suitable to collect feedback about hotels and may also play a role in the upgrading of a hotel's evaluation. Eventually, a positive trend towards better feedback when evaluating a hotel through the use of a robot compared to a website was indicated (Lein et al., 2023).

3.2.5. COVID-19, Digitalization, and Increase in Effective Technological Innovations, AI, and Robotic Services

As highlighted by all studies, the COVID-19 pandemic has substantially accelerated digitalization and brought the need for the integration of new technological innovations to light. Especially in the hotel and restaurant industry, as the studies presented below note, the increase in these services is only expected to grow.

Guan et al. (2022) mention that in the future, robots will be more deeply integrated into the provision of tourism reception and that the market for service robots will also develop substantially. This information is also noted by Seo and Lee (2021); specifically, the professional and personal use of service robots is reported to be growing at 30% a year, and it is expected that the demand for service robots will continue to increase (Guan et al., 2022; Seo & Lee, 2021). Pillai et al. (2021) investigated the effects of the current COVID-19 pandemic and also past disasters on the global hospitality industry and how the industry responded to them. By identifying hygiene and cleanliness as important factors for the longevity of hospitality operations, this study further explored the role of technology in ensuring hygiene and cleanliness. As the researchers note, hygiene, cleanliness, and safety have arisen as major factors for the tourism experience, especially after public health disasters such as the 2003 SARS outbreak. As is also mentioned, the existing literature has shown that hygiene, cleanliness, and safety protocols are the most important measures taken by businesses in the hospitality and tourism industry, both during and post-epidemic/pandemic times. In order to enhance these measures, decrease COVID-19 transmission, and enhance the feeling of safety and satisfaction for the customers, the hotel industry will more and more often embrace technology-enabled solutions to provide contactless services (Pillai et al., 2021).

This article introduces the term Hospitality 5.0, referring to how contactless technology can lead to hygiene, safety, and cleanliness in customer journeys. Pillai et al. (2021) mention that the components of Industry 5.0 consist of the human–cyber–physical system (HCPS), the internet of things (IoT), and the internet of service (IoS). As already mentioned, sensors have a major role in the HCPS. The HCPS's implementation in the tourism sector will provide an enhanced level of food safety through the integration of sensors that can scan for diseases and also assess the parameters of freshness and hygiene of products and smart food labels. This would be extremely helpful in enhancing the overall health and safety level in hotel restaurants. Additionally, the IoS is used to connect IT to guest services. Typically, information like restaurant services and room availability are often services not standardized in hotels. The IoS can provide the versatility and efficiency needed to better serve hotel customers and move information through its channels (Pillai et al., 2021).

Once again, the valuable role of integrating contactless technologies like electrostatic sprayers, ultraviolet light automated air purifiers, built-in air sensors, and advanced particle removal technology-enabled air purification devices that facilitate the removal of virus particles is highlighted in achieving the goal of creating an environment that ensures hygiene, cleanliness, and safety. Pillai et al. (2021) also provide results about the integration of robots and effectiveness during the COVID-19 pandemic, stating that the existing literature concluded that robots were found to be particularly effective in China during the COVID-19 pandemic for routine or non-routine tasks using ultraviolet (UV) for surface disinfection (Pillai et al., 2021).

Finally, the systematic review of Elkhwesky et al. (2024) focused on sustainable innovation in the tourism industry in order to deal with the COVID-19 crisis, enhance resilience, and acquire survival potential for the post-pandemic period. The study critically reviewed the literature on the topic of sustainable innovation in hospitality and tourism in order to categorize prevalent types and outcomes of sustainable innovation. Overall, 58 articles were reviewed. The main conclusion drawn was that since the beginning of COVID-19, there has been a significant enhancement in the utilization of network technologies (especially social media and digital platforms) in the hospitality industry. Moreover, data-processing technologies like AI and Machine Learning (ML) are integrated more and more in comparison with physical–digital interface technologies like Virtual Reality (VR) (Elkhwesky et al., 2024).

Davahli et al. (2020) also conducted a systematic review in order to investigate information about the operation of the hospitality industry during the COVID-19 pandemic. Overall, 50 papers were reviewed. The articles focused on aspects of the tourism industry regarding hospitality workers' issues, revenue impact, the COVID-19 spreading patterns in the industry, market demand, safety and health, travel behavior, and the preferences of customers. Through the analysis of the studies, Davahli et al. (2020) concluded that several recommendations about actions that can be implemented by restaurants and tourist accommodations in order to enhance safety and cleanliness levels included island-sitting arrangements to ensure enhanced levels of physical distance between people, live cooking counters to allow customers to watch their food being prepared and therefore further enhance the level of confidence, and also appropriate hygiene and cleaning procedures (Davahli et al., 2020).

## 4. Discussion

The main conclusion drawn through our systematic review is that maintaining a high level of hygiene and cleanliness conditions in hotels and restaurants will always have a major impact on customers' booking intentions. Moreover, as concluded from almost all studies, the pandemic does appear to have been the starting point for the acceleration of digitalization in hotels and restaurants and also for customers to begin adopting a new perception towards establishments that will from now on include a moderate-to-high level of new technological strategies for protecting customers' health and also decrease the risk of the transmission of viruses like SARS-CoV-2 (Buhalis & Moldavska, 2022; Davahli et al., 2020; Elkhwesky et al., 2024; Guan et al., 2022; Kim et al., 2021; Pillai et al., 2021; Roussakou & Carayanni, 2024; Ye et al., 2022).

Studies revealed that there are many different parameters that affect the level of acceptance of customers towards the integration of new technologies in hotels and restaurants. The most significant ones include cleanliness level, the overall perception of guests about the level of the effectiveness of these measures against infection risk, the perceived usefulness and ease of use of the robots, the servicescape of robot restaurants, and service competence. During health-related crises, the acceptance levels towards contactless services increase, as well as the overall positive perception towards robots and AI. However, the human factor is always a very important aspect of the hotel and catering industry that cannot so easily be replaced by robots (Guan et al., 2022; Nozawa et al., 2022; Seo & Lee, 2021).

Regarding the topic of effectiveness, even though we have quite valuable information obtained from some of the studies, it appears that so far there are only a few studies exploring new technology's effectiveness in the tourism sector and hotel restaurants. Specifically regarding effectiveness, we were searching for studies that have conducted field measurements on particulate matter presence, air quality, and also surface contamination in hotels and restaurants. The only studies that appear to fit in this section are Chang et al. (2021)

and also Lein et al. (2023), while the rest of the studies mostly focus on customer perceptions and behaviors towards the integration of AI and robots (Chang et al., 2021; Lein et al., 2023; Roussakou & Carayanni, 2024).

"Cleanliness" is cited by all as a determinant of overall satisfaction of customers and perceived service quality. Regarding the restaurant sector, improved food safety can be further enhanced through the development of sensors to scan for disease and assess product hygiene. Restaurants and hotels must constantly try to reinforce transmission mitigation measures (Buhalis & Moldavska, 2022; Romero & Lado, 2021; Roussakou & Carayanni, 2024; Xu et al., 2022).

Additionally, the enhancement of the integration of air purifiers in tourism and restaurants is a very significant measure in the fight against virus transmission. Though the topic was not highly researched in the various studies, it was generally noted that contaminated air and overall airborne transmission are the most important contributors to the increase in COVID-19 cases; therefore, these devices deserve much more attention, as noted by Xu et al. (2022) and especially Chang et al. (2021), who highlights the need for enhanced indoor air ventilation systems in hotels and restaurants (Chang et al., 2021; Duval et al., 2022; Roussakou & Carayanni, 2024; Xu et al., 2022).

Regarding prevention efficacy, results from various studies indicate that robots are considered an appropriate means to reduce COVID-19 contagion risk. Specifically, in the study of Romero and Lado (2021), results regarding the integration of service robots at hotels, suggest that Generation Z individuals consider that technological solutions utilized in order to enhance social distancing are efficient in the reduction in COVID-19 contagion risk. The specific outcome is also noted by Guan et al. (2022), and, overall, it has been highlighted by various studies that claim that intelligent reception, unmanned retail, and unmanned distribution in the tourism and catering industries can both effectively reduce the risk of cross-infection between individuals and also provide the basis for the popularization of the use of service robots (Guan et al., 2022; Romero & Lado, 2021).

Tourists' perceptions of security and privacy in hotels have also increased since the pandemic, and consequently, the implementation of measures for the reduction in perceived health risk is mandatory (Kim et al., 2021; Xu et al., 2022).

Aside from digitalization, the pandemic appears to have accelerated the need for technological innovations to be included in hotels and restaurants, since they can enhance business operation and business recovery, but most importantly, technology appears to have a major impact on overall market value, brand trust, positive ratings, and revisit intention (Arica et al., 2023; Hsieh et al., 2021; Lein et al., 2023; Sharma et al., 2021; Shin & Kang, 2020; Vandenhaute et al., 2022; Wei et al., 2021).

All studies' results including consumers' and stakeholders' opinions indicate that hotels and restaurants should continue to reinforce measures and new technologies for cleanliness, food safety, and employee/customer hygiene (Chang et al., 2021; Lein et al., 2023; Roussakou & Carayanni, 2024; Xu et al., 2022).

Overall, the most interesting conclusions from the studies include the positive consequences of robotic applications in the tourism sector, such as the increase in customers' acceptance of robot use and robot service, which will provide a more efficient armory for fighting the negative consequences of any future pandemics that may appear. Additionally, the adoption of robots during times when minimization of face-to-face contact is required, as well as social distancing, appears to play a major role in restoring customer satisfaction and supporting business recovery (Buhalis & Moldavska, 2022; Kim et al., 2021; Lu et al., 2020; Romero & Lado, 2021; Ye et al., 2022).

Furthermore, it appears that the strategy of robot implementation in hotels and restaurants is connected to perceptions about the differences between human and non-human services. The factors of emotional attachment and empathy have been considered crucial for enhancing customer satisfaction. In the study by Kim et al. (2021), human staff were considered better than service robots in making guests feel emotionally attached to the hotel brand and providing them with an enriching experience (Kim et al., 2021).

The various results provide quite a clear clarification that the pandemic brought cleanliness, hygiene, safety, and also technological innovation to the front row in order to fight virus transmission and enhance the hygiene protocols applied in hotels and restaurants. The new era must, however, try to keep a balance between human and non-human service implementation. Let us not forget, even though it is not highly researched in our review, that through the analysis of the different studies, one main conclusion is that anthropomorphism is not globally acceptable, the ability to use robots and AI is a factor that appears to be affected by variables such as age and culture, and, finally, skills like empathy and communication are prominent for enhancing the restaurant and traveling experience and also dictate the constant presence of humans as service providers. In the study of Ye et al. (2022), it was also concluded that non-humanoid service robots were more acceptable than humanoid robots among hospitality and tourism consumers (Ye et al., 2022).

In summary, it is clear that today, more than ever before, the hotel and restaurant industry needs to frame prevention and active management strategies to minimize the negative impact of COVID-19 on multiple levels of its function.

New technologies such as artificial intelligence including service robots, ventilation systems, and self-service technologies are increasingly adopted by the hospitality and catering industries in order to achieve new health and safety standards.

Enabling contactless technologies such as automated UV air purifiers, built-in air sensors, and advanced air purifiers with particulate matter removal technology is also a rapidly growing sector. Innovations are very important in the effort to improve efficiency and productivity and increase customer loyalty in the tourism sector.

The use of robots and AI in tourism is an emerging field of research (hygiene issues, contactless services, check-in, reservations, development of voice assistants) with quite positive results provided so far. High-efficiency robots using ultraviolet (UV) radiation to disinfect surfaces have been considered very efficient in their implementation (Davahli et al., 2020; Elkhwesky et al., 2024; Pillai et al., 2021).

The human–cyber–physical system (HCPS), the internet of things (IoT), and the internet of service (IoS) are going to play a key role in all innovations that may be developed in the future. In addition, anthropomorphism appeared to increase the perceived effectiveness of preventing COVID-19 and create a greater willingness to book for Gen Z customers. In all cases, businesses must continue to strengthen health and safety measures since hygiene measures as well as organizational measures appear to have a big impact on the profitability of businesses.

Particulate matter (PM) has arisen as a major contributing factor to health problems and the spreading of diseases; however, the main conclusion from our review is that there is unfortunately still a huge literature gap about PM, SARS-CoV-2, and the contribution of air purifiers to indoor air quality. The study conducted by Chang et al. (2021), included in this review, used a series of field tests to assess real-time  $PM_{10}$  and  $PM_{2.5}$  concentrations in the dining room of an open-kitchen, full-service, chain-operated restaurant as a case study. The results of the one-week-long study revealed hazardous indoor PM pollution in the dining room of the open-kitchen restaurant, specifically that commercial cooking emits an excessive level of indoor PM concentration (Chang et al., 2021; Roussakou & Carayanni, 2024).

Considering all the above, hotel restaurants, especially open-kitchen restaurant brands, should consider implementing new mechanical dining room ventilation systems similar to kitchen hood ventilation.

Safety measures that can contribute immensely to enhancing the health and safety level of hotels and restaurants are ventilation systems that filter indoor air, QR code catalogs, e-services regarding online check-in, and e-keys for room access. Moreover, portable air purifiers with high-efficiency particulate air filters are another excellent solution.

It is evident that the emergence of service robots provides a new opportunity for the tourism and catering industry. With the rapid development of this technology, tourism and hotel catering are increasingly integrating service robots into their offerings. Enterprises should also adopt education, publicity, and other ways to guide customers to form a more positive attitude towards robots.

Considering possible limitations of our study, it is important to note the small number of studies included; the cross-sectional design, which does not allow for causality conclusions; and the heterogeneity in methodological approaches, which does not permit any statistical analysis (Roussakou & Carayanni, 2024).

Further studies with longitudinal data are necessary to further unravel the complex interplay between new technologies, health and safety in hotel restaurants, and customer satisfaction.

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