

A wearable technology solution and research agenda for housekeeper safety and health

Wearable
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solution and
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Abstract

Purpose – Adopting an interdisciplinary perspective, the purpose of this paper was to posit an industry-wide technological intervention for hotel housekeeper safety and health through the advancement of wearable technology.

Design/methodology/approach – Using the task-technology fit (TTF) model and examples of successful safety and health applications of wearable technologies in the health-care and construction management industries, interventions and future research directions are presented to address workplace hazards experienced by hotel housekeepers.

Findings – The fit between a variety of hotel housekeeper user requirements, task demands and wearable functions are explored with justification for the use of wearable devices to improve safety and health-related outcomes.

Research limitations/implications – A research agenda is proposed for the adoption and use of wearables in the hospitality industry with the intention to generate meaningful interventions beyond corporate wellness, and the mitigation of employee privacy concerns to enhance wearable adoption.

Practical implications – Given the importance of consumer safety and health assurance in a post-pandemic business environment, hospitality and tourism organizations should place greater emphasis on protecting front line employees who will be essential in regaining economic viability.

Social implications – Theoretical and practical foci should move beyond a simplistic view of hospitality and tourism worker safety and health that generally centers on wellness initiatives and other baseline strategies, toward a more holistic view benefitting the hospitality industry.

Originality/value – Extant concerns about hotel housekeeper safety and health, in addition to new concerns and threats in a post-pandemic work environment, are largely understudied and worthy of investigation.

Keywords Occupational health, Hospitality industry, Information privacy, Wearability, Task-technology fit (TTF)

Paper type Conceptual paper

Hotel housekeepers are an essential hotel workforce who will carry out the cleaning and sanitizing tasks which will be crucial for regaining consumer trust post-pandemic. In addition, they are an at-risk group disproportionately affected by a variety of work-related



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hazards and adverse health outcomes. The ramifications of COVID-19 have heightened threats to hotel housekeeper safety and health, with unknown consequences across the global hospitality industry, illustrating the urgency for protecting housekeepers. Intensifying this situation are the effects of previously established income insecurities, along with increased housekeeper workloads as the hotel industry navigates through the COVID-19 pandemic (Rosemberg, 2020). While the safety and health concerns brought about by the pandemic are certain to generate a substantial body of hotel employee safety research in the coming years, there still remains a research gap pertaining specifically to the physical safety and health of hotel housekeepers. This small stream of research risks attenuation, as the emphasis on the economic return of the hospitality sector will take precedence until the industry recuperates (Davahli *et al.*, 2020). Closer examination of housekeeper safety and health is warranted, along with an exploration of potential interventions that the hospitality industry might leverage to mitigate threats to safety and health both during and after the global pandemic. One possible intervention includes the use of wearable technology already widely adopted among consumers and within various occupational sectors.

Prior wearable technology research in the hospitality context has focused on either the use of consumer augmented or virtual reality wearables (Flavián *et al.*, 2021; Tussyadiah, 2013; Tussyadiah *et al.*, 2018), the use of hospitality employee wearables in serving guests (Buhalis *et al.*, 2019; Wu *et al.*, 2015), or on corporate health initiatives using wearables for step counts and other health-related tracking purposes (Torres and Zhang, 2021; Zhang *et al.*, 2020). To the best of our knowledge, no study or conceptual paper to date has explored the use of wearable technology for the health and safety of hospitality employees outside of basic health-tracking measures. Based on an interdisciplinary approach using the task-technology fit (TTF) model, the purpose of this conceptual paper is to present a critical analysis of the literature in the understudied area of hotel housekeeper safety and health, thus advancing a more holistic role of wearable technology in the hospitality industry. The objectives of this paper include:

- to examine how commonly experienced hotel housekeeper health risks and safety hazards may be ameliorated through wearable technology use;
- to explore broader organizational elements for wearable safety technology adoption in the hospitality industry, with examples borrowed from other occupational disciplines;
- to consider factors such as employees' aesthetic preferences for wearable devices and concerns regarding their personal information privacy as predictors for adoption among hotel housekeepers; and
- to present a research agenda for inclusion in the hospitality context to protect hotel housekeeper safety and health in the post-pandemic service environment.

Literature review

Hotel housekeeper safety and health

The US Department of Labor Occupational Safety and Health Administration (OSHA) categorizes five hazards related to workplace injuries, illnesses and incidents. These include safety, chemical, physical and biological hazards, along with ergonomic risk factors [Occupational Safety and Health (OSHA), 2020] of which hotel housekeepers suffer disproportionately (Streit, 2015). The majority of hotel housekeeping staff in the USA consist of immigrant women who are paid among the lowest wages in the industry, yet experience the highest risks to health and safety, including the highest injury rate in hospitality work environments (Hsieh *et al.*, 2013, 2016; Rosemberg *et al.*, 2019; Streit, 2015).

Vulnerability to violence in the workplace

Hotel housekeepers are often female, low-skilled workers with minimal specialized skills and training, often in contrast with the hotel guests whom they serve (Yagil, 2008). These differences in social status create a power imbalance, which in service situations can lead to customer aggressions such as yelling, threats, condescension, racist comments, swearing, and fighting with line level employees (Nimri *et al.*, 2020; Ram, 2018; Yagil, 2008). Hotel housekeepers are viewed as subservient and vulnerable in their roles and are subjected to frequently normalized sexual harassment and assault. As the hospitality industry is based on a customer-centric culture, hotels are limited in the extent to which they can control customer behaviors (Kensbock *et al.*, 2015; Nimri *et al.*, 2020; Shanker *et al.*, 2015). Irregular nights, weekend and holiday hours worked by many housekeepers can make them vulnerable to violence because they often work alone, outside of the eyesight or earshot of coworkers and supervisors (Irwin *et al.*, 2019; Morken *et al.*, 2015) and may lack social relationships and support due to their social isolation at work (Streit, 2015).

In addition to threats to potential violence and sexual harassment within customer-employee interactions, line level female workers in the hospitality industry also endure sexual harassment and aggression from their coworkers, which is difficult to identify and control (Morgan and Pritchard, 2019; Vagianos, 2015). Structural causes in the hospitality industry for coworker aggression and sexual harassment largely impacts young female minority workers who due to their income insecurity have a high dependence on supervisors and managers for scheduling their work hours (Ram, 2018). Largely under-researched in the hospitality and tourism literature, scholars have long called for an interdisciplinary approach to examine the dynamics of customer-employee and employee-employee interactions leading to sexual harassment and assault, in addition to the interventions which could address and mitigate the prevalence of sexual harassment incidences in the industry overall (Ram *et al.*, 2016).

Chemical, physical, and biological hazards and stress

Hotel housekeepers are subjected to an unequal distribution of adverse physical and psychological health outcomes compared with other service sector jobs (Hsieh *et al.*, 2016) and are susceptible to multiple sources of job stress including high workloads, low control/autonomy, long working hours, and demanding customers, leading to higher levels of injury and burnout (Chiang and Liu, 2017). The unequal distribution of power among the hotel workforce as a result of labor stratification may contribute to the health and safety disparity experienced by housekeepers. Employees with less power experience worse occupational outcomes based on increased exposure to occupational hazards, including chemical hazards, biological hazards and job insecurity. Lower power employees are also less likely to influence work-related policies and practices, which could help protect employees when tailored to their specific vulnerabilities and needs (Landsbergis *et al.*, 2014; Streit, 2015).

Exposed to harmful chemicals, such as ammonia and solvents in cleaning products, hotel housekeepers suffer from prolonged contact with these chemical agents, which often intensify dermatitis, respiratory diseases and other health conditions (Hsieh *et al.*, 2016; Lin *et al.*, 2020). Employees who work with cleaning chemicals are also susceptible to allergic reactions and skin rashes from long and constant use of latex gloves (Kline *et al.*, 2014). The number of rooms required to clean per shift of up to 15 per day on average, expose housekeepers to repetitive motion injuries and overexertion, attributed to physically demanding tasks including making beds, lifting furniture, and moving cleaning equipment (Harris-Adamson *et al.*, 2019; Hsieh *et al.*, 2016; Streit, 2015). Hotel housekeepers endure a higher rate of musculoskeletal disorders than any other type of hotel worker

(Buchanan *et al.*, 2010), resulting in lost work of up to 6 days per year on average (Premji and Krause, 2010). Housekeepers who work in exterior-corridor hotels, clean rooms without consistent air-conditioning, complete laundry-related tasks, or work for hotels in particularly hot or humid regions may also be at risk for heat stress and heat exhaustion after being exposed to extreme heat or working in these hot environments (Ambardar, 2015; Kjellstrom *et al.*, 2013).

The cumulative effects of chronic stress, job strain and job insecurity contribute to the allostatic load, poor mental and physical health, and chronic health conditions experienced by housekeepers (Rosemberg *et al.*, 2019; Sönmez *et al.*, 2020). Compounding the problem, hotel housekeepers have fewer recovery opportunities, such as psychological detachment and relaxation, due to multiple competing responsibilities at home and at work (Lee *et al.*, 2016). When injured or ill, hotel housekeepers may also have more difficulty accessing health care, an issue especially problematic for those who lack English proficiency, are immigrants, or are contracted workers (Hsieh *et al.*, 2016).

COVID-19 and other infectious diseases

As a result of travel restrictions and numerous shutdowns caused by the COVID-19 pandemic, the global hospitality and tourism industry is one of the most adversely impacted sectors. Already disproportionately affected, vulnerable, and income insecure workers before the pandemic, hotel housekeepers are eager to return to work post-pandemic (Sönmez *et al.*, 2020). This dynamic and the close physical proximity requirements in their jobs may result in a higher incidence for the spread of illnesses among housekeepers. They are more likely to be exposed to guests' body fluids or needles while cleaning, increasing the risk of contracting blood borne and other respiratory infections (Kline *et al.*, 2014; Moyce and Schenker, 2018) of significance during and after COVID-19 (Sönmez *et al.*, 2020). Emerging literature in this area stresses concerns regarding how housekeepers may be at greater risk for bringing home the COVID-19 virus and infecting their family members due to a lack of paid time off for quarantine, increased workloads, and inadequate training on proper disinfection techniques (Rosemberg, 2020).

Along with the CDC rules for hotels and restaurants, many researchers have recommended a series of actions to decrease infectious disease and COVID-19 workplace transmission. For instance, researchers have studied Internet of Things (IoT) technologies, such as drones and wearables, with respect to proximity-detection functionalities and e-health monitoring that could be a useful tool for monitoring the spread of infectious diseases in the workplace (Nasajpour *et al.*, 2020). Prior research in this area has demonstrated the benefits of wearable technology tracking capabilities, which includes notifying the user when a confirmed infected individual is within close proximity (Shubina *et al.*, 2020). These proximity detection notifications have been found to encourage individuals to activate a variety of protective measures such as self-quarantine, undergoing a COVID-19 test, and other proactive courses of action to reduce the transmission rate while at work or in the local community (Shubina *et al.*, 2020).

Medical wearable devices have existed for quite some time, however, due to the COVID-19 pandemic and the emergence of other infectious diseases, global technology firms have innovated wearable devices to integrate medical functions, thus impacting a greater consumer population. An example of a recent practical application of physiological assessment in a wearable device is the Apple Watch Series 6, which allows the measurement of blood oxygen levels (SpO₂) from anywhere and at any time, fulfilling a much-needed purpose in the recent pandemic (Apple, 2021; Mitroff, 2020). Hence, wearables devices are becoming increasingly essential as they alert wearers on their physical health conditions, prompting fewer physical visits to clinics (Wang *et al.*, 2020) and reducing overall health-

care costs (Li *et al.*, 2016). Beyond the COVID-19 pandemic, and as new and recurring infectious diseases emerge (i.e. influenza), wearable technology devices can continue to benefit hospitality workers and organizations via their many physical and health tracking functions which promote employee health, thus mitigating disease spread.

The above concerns for hotel housekeeper safety and health, in addition to the rapid technological evolution of wearables both prior to and as a result of the pandemic, underscore the necessity for an industry-wide intervention. Like previous initiatives of successful technology-based solutions implemented to ensure consumer safety (Bantau and Rayburn, 2016; Bonfanti, 2016; Cobos *et al.*, 2016), the hospitality industry already has the capability to enact the adoption and use of a wearable technological intervention to protect the safety and health of hotel housekeepers.

Wearable technology

Wearable technology is classified as “all forms of computational or sensory electronic devices that can be worn with clothing or on the body (Fernandez, 2014). Popular consumer wearables include Google glass, iWatch, Samsung Galaxy Watch, Fitbit and an abundance of other ‘smart clothing’ technologies (Lee *et al.*, 2016). Driven by a surge in adoption among Gen Y consumers, by 2027 the wearable market is anticipated to reach US\$52.41bn in the USA, and US\$104.39bn globally (PR Newswire US, 2020). In addition to the popularity exhibited in the consumer market, wearable technologies have proliferated across other contexts, particularly in the health-care and construction industries. Providing patients and doctors with more efficient and integrated communication solutions to monitor health (Baker *et al.*, 2017) and construction workers with safety technologies to better detect and manage worksite hazards (Ahn *et al.*, 2019), wearable devices are increasingly employed among stakeholders of these industries.

Wearable use in the health-care and construction management industries

Wearables primarily focused on health management are known as ‘Healthcare Wearable Devices’ which incorporate sensors to collect behavioral, physiological, and environmental data (Wang *et al.*, 2020). The increasing miniaturization of microprocessors and biosensors has enabled health-care wearables to serve multiple simultaneous functionalities including text messaging, receiving calls, geo-mapping and navigation, calorie counting, emergency and security notifications, and health management feedback all in real time (Baker *et al.*, 2017; Park, 2020). Gao and colleagues (2015) categorized health-care wearable devices into two types: (1) Those designed for fitness; and (2) Those designed specifically for medical purposes. Fitbit is an example of a fitness wearable device that is used to track an individual’s physical activity, food intake, weight, and sleep patterns. Based on the information collected, the Fitbit device provides fitness-related suggestions to improve consumer health and wellness (Wang *et al.*, 2020). In contrast, medical wearable devices surpass physical tracking capabilities and provide wearers and their physicians with comprehensive personal health data such as oxygen levels, gene expression, blood pressure, and personalized medical suggestions that allow the wearer and the physician to manage serious diseases (Li *et al.*, 2016). Thus, health-care wearable devices offer many advantages to both patients and medical professionals in the health-care industry and have become increasingly prevalent in the health-care field, serving a variety of purposes ranging from monitoring patients’ vital signs to providing assistance during surgeries (Iqbal *et al.*, 2016).

In addition to use in the health-care sector, wearable technologies have been successfully adopted in the construction industry for proactively identifying safety and health risks and as a means of continuous monitoring of employees in hazardous work environments

(Ahn *et al.*, 2019). Similar to housekeepers, high levels of physical demands are inherent to most construction workers' jobs, putting them at elevated risk for work-related musculoskeletal disorders and other health and safety issues associated with physical strain and fatigue (Fang *et al.*, 2015). Although wearable technology has yet to experience universal adoption across the industry (Zack, 2016), construction companies are reporting the increased use of wearable sensing devices for the purpose of occupational safety and health management (Nnaji and Karakhan, 2020). Prior research has identified a variety of ways in which wearable devices complement existing construction safety technology, improving health and safety management through both proactive risk identification and real-time risk monitoring (Awolusi *et al.*, 2018).

Ahn *et al.* (2019) identified five notable applications of wearable technologies investigated in construction contexts including the prevention of work-related musculoskeletal disorders, averting falls, evaluating physical workload/fatigue, recognizing hazards and surveying worker mental health. Although some of these applications are similar to those found in the health-care sector, such as physiological monitoring (Guo *et al.*, 2017), other wearable device applications are more specific to the physically demanding work of construction and use wearable mobile sensors to monitor body posture and identify ergonomic risks (Nath *et al.*, 2017).

The construction and health-care literatures have explored many applications for wearable devices and their functionalities, which offer justification for the use of wearable technology to augment safety and health at work. These applications extend beyond the limited use of wearables for fitness purposes, thus demonstrating this technology's ability to address a variety of health and safety risks including physical fatigue, stress, and biological, physical and chemical hazards. The service-related features of the health-care industry, accompanied by the concerns for safety in the construction industry, mirror many of the health and wellness concerns experienced by hospitality employees, bolstering the argument for how health and safety applications of wearables in these industries should help to provide a pathway for the adoption and use of wearable devices in the hospitality industry.

Wearable device research in the hospitality industry

Although wearable devices have been conferred as an important emerging technology in hospitality and tourism (Atembe, 2015), research from the discipline has only recently advanced wearable technology adoption and use for the safety and health of hotel workers. Historically, wearable research in the hospitality and tourism discipline has often focused on hotel guests, rather than on employee technology use (Chen *et al.*, 2018), and studies specifically examining safety and health have tended to be more limited in scope and application, focusing primarily on the use of wearables within the context of employee wellness programs. Specifically, recent studies have addressed occupational health and related initiatives from the standpoint of wellness programs and the use of wearable devices to track hospitality employees' activities and sleep patterns (Torres and Zhang, 2021, 2020). Torres and Zhang (2021) tested the effects of a technology-based wellness intervention with hospitality employees using Fitbit to actively alter participants' behavior in ways that benefit employee health and work-related outcomes. Their findings demonstrated that the use of wearable technology improved employee engagement, organizational commitment, and job satisfaction (Torres and Zhang, 2021). This suggests that wearable devices, such as activity trackers, can be effectively used in hospitality organizations as a key aspect of a technology-based health intervention, promoting health and wellness in hospitality employees. While not reported as a finding, the researchers also addressed issues

concerning employees' privacy of information, and advocated for transparency in data usage, storage, and access (Chung *et al.*, 2017; Torres and Zhang, 2021). Additionally, Zhang *et al.* (2020) reported that wearable activity trackers measured important health metrics, which were recommended for inclusion in a variety of health interventions and strategies such as ergonomic equipment for musculoskeletal problems, job rotations for those who sit for long periods of time, and improved scheduling for mitigating sleep-related issues and accidents. A limited number of employee-centric hospitality studies have focused on wearable device use beyond wellness interventions, including Wu *et al.*'s (2015) research on front-line employee wearable use and its impact on guests' perceptions of service encounters. Despite this small stream of wearable research for the safety and health of hospitality employees, this literature is undeniably in need of expansion both practically and theoretically (Gonzalez, Gasco, and Llopis, 2020). Specifically, additional research is needed to broaden our understanding of wearable technology applications beyond that of wellness programs to address the numerous unstudied ways that wearables may help abate health and safety issues frequently experienced by hotel housekeepers.

Theoretical framework

Wearable devices offer specialized characteristics and functions influencing their adoption and use, which must be considered when implementing a technology initiative in a work environment. To justify a wearable technology investment, rather than purchasing inexpensive safety-related panic buttons on the market, it is imperative to explore how the wide range of wearable functionalities substantially enhances the safety and health of hotel housekeepers beyond that of alternative technologies. The TTF model provides theoretical underpinnings to gather evidence for how and why wearable technologies can be the most effective technological intervention for protecting hotel housekeeper personal safety and health.

Task-technology fit model

Technology acceptance models are useful in predicting individuals' intentions to adopt and use a technology according to a variety of predictors such as perceived usefulness, perceived ease of use, facilitating conditions, compatibility, observability, and social influence (Venkatesh and Bala, 2008; Venkatesh *et al.*, 2003). Nevertheless, these models are criticized for an inability to consider whether wearable technology possesses the required functions to carry out desired outcomes, which can be captured by the TTF model (Al-Jabri and Sohail, 2012; Venkatesh and Bala, 2008; Wang *et al.*, 2020).

The TTF model predicts technology-related outcomes by investigating how the fit between technology, task and user characteristics or attitudes influence employee adoption of a technology and the performance benefits associated with the use of that technology (Goodhue and Thompson, 1995; Furneaux, 2012). According to the TTF model, when technology functionalities are compatible with job task demands, more desirable outcomes will emerge (Goodhue and Thompson, 1995). If a specific technology fails to match job demands because it does not possess features or functions that meet the task requirements, performance outcomes will decrease, regardless of how often or how well the technology is used (Goodhue, 2006). From this perspective, there is no singular 'most effective' technology for completing job tasks, but rather the characteristics and demands of various tasks are dependent on a variety of functionalities within a technological solution (Lee *et al.*, 2007). For technology to positively impact performance or other task-related outcomes, it must be used by employees and possess those functionalities which address the requirements of tasks deemed important. For example, in the hotel housekeeping context, while mobile tablets are

effective devices for helping housekeepers manage their workload by organizing and communicating room assignments, these devices may be less helpful during a safety emergency because they may lack the location tracking capabilities needed to quickly find a worker and send assistance. Similarly, mobile technologies may lack important functions for contact tracing that allow for tracking workers who come in contact with infected individuals or who are exposed to chemical or biological hazards.

According to the TTF model, workers will be more likely to accept and use technology that appears to demonstrate personal or work-related benefits enhancing the efficiency and/or effectiveness of their work processes (McCartney and McCartney, 2020; Wang *et al.*, 2020). This focus on individual adoption indicates that employee perceptions of TTF may be particularly important in contexts where individuals work independently or alone, such as the case with hotel housekeepers. TTF is also important where the use of a specific technology is difficult for supervisors to enforce, although research has supported the predictive validity of this model in both mandatory and voluntary adoption contexts (Goodhue *et al.*, 2000). Finally, although research has tended to focus on the alignment between user requirements/needs and technology functions, user characteristics such as self-efficacy or individual differences in privacy concerns, can interact with technology capabilities to predict task performance while influencing user perceptions of TTF (Kim *et al.*, 2015; Serrano and Karahanna, 2016).

In prior technology adoption models, fit has often been implied rather than directly measured such that individuals are not expected to use technology that fails to meet task needs or adoption. However, that may not always be the case, as in many jobs the use of specific technologies is mandated, thus imposing greater emphasis on TTF over adoption models in contexts where technology use is difficult to mandate (Goodhue, 2006). Fundamentally, the TTF model argues that to understand the potential advantages associated with the adoption and use of a new technology, the characteristics of the technology, the worker, and the nature of the work itself, should not be considered independently. Instead, stakeholders should investigate how tasks, technology, and attitudes collectively interact to influence the outcomes associated with employees using a specific technology within a given work context (McCartney and McCartney, 2020). Our review employs the TTF framework to explore how the use of wearable devices can improve employee health and safety outcomes because the characteristics and functionalities of this technology fulfill the health and safety demands of hotel housekeepers. Wearable devices should be considered for adoption among hotels because the variety of wearable functions available are able to fulfill the health and safety needs of housekeepers in ways that other simple technological solutions, such as panic buttons and mobile devices, do not.

Wearable device functions and fit with task demands

According to the workplace hazards identified by the US Occupational Safety and Health Administration, user requirements in the workplace can be framed relative to health and safety-related needs such as signaling for help during an emergency, in contact tracing or identifying stress and illness (OSHA, 2020). Similarly, while wearable technologies are capable of a wide range of functions related to human-environment tracking (Kamišalić *et al.*, 2018), the focus for successful wearable adoption should be on the technology functions and sensor types that are relevant to the specific needs of hotel housekeepers. A review of wearable device functionality literature provides evidence of frequently experienced workplace stressors and hazards, together with specific wearable functions for addressing risks to safety and health (Ahn *et al.*, 2019; Khakurel *et al.*, 2018; Kamišalić *et al.*, 2018).

Additionally, because a wide range of wearable technology is available in the consumer marketplace, specific types of wearable devices and sensors can be envisioned for completing a variety of functions, such as recognizing employee illness through physiological sensors, for example. Finally, targeted safety and health outcomes to meet specific housekeeper safety and health needs reveal the connection between the OSHA stated workplace hazards (2020), the housekeeper/user requirements, and wearable device functions (see [Tables 1–4](#)). Overall, the goal is to provide evidence and practical implications for why a wearable technology intervention could be successful in addressing hotel housekeeper safety and health.

Factors that influence wearable adoption

While the TTF model argues that the degree of fit between technology and consequential tasks directly affects technology adoption and use, other models explicitly highlight attitudes and beliefs as important mechanisms influencing behavioral intention to use a technology ([Dishaw et al., 2004](#)). Thus, while evidence of the fit between wearable functionalities and housekeeper safety and health demands may demonstrate the value of a wearable technology adoption, it is essential to also discuss those external factors with the potential to positively or negatively impact use, regardless of the level of fit. Perceptions of privacy concerns, device wearability, and aesthetics are all factors that have been recognized as particularly influential in predicting the use of wearable technology due to the unique characteristics possessed by these devices and the sensitive nature of the broad range of data potentially collected ([Niknejad et al., 2020](#); [Torres and Zhang, 2021](#)). Beyond individual adoption, additional factors such as return on investment (ROI) can influence a hotel brand's willingness to engage in large scale organizational or departmental-level adoption of wearable devices, particularly if the benefits of investing in wearables clearly exceed those of less expensive technological alternatives with fewer functionalities.

Wearability and aesthetics

The greatest influences on wearable adoption and use includes how the device “wears” (wearability) and the appearance of the device (aesthetics), in addition to what these characteristics are perceived to indicate about the technology. “Wearability” refers to the interaction between an individual's body and the wearable device ([Gemperle et al., 1998](#)) with devices that are comfortable, lightweight, breathable, and easy to wear and remove generally viewed as more wearable ([Marculescu et al., 2003](#)). Wearability can affect the adoption and use of a technology as employees are more motivated to engage with wearable devices that are designed with comfort and durability as a priority ([Hamper, 2015](#)).

In contrast to the feel of a wearable device, the aesthetic characteristics refer to the visual features, such as the style and color of the device, and the materials used ([Fiore and Damhorst, 1992](#)). Previous consumer behavior research has indicated that wearable devices are often viewed as fashion accessories as well as functional devices, such that the appearance of a device and its visual design can influence how satisfied individuals are with wearables, and thus more likely to adopt ([Jeong et al., 2017](#)). Overall, research has found that wearability and aesthetics have a significant impact on employees' adoption of wearable devices ([Choi et al., 2017](#)), with [Dehghani et al. \(2018\)](#) finding that design characteristics, device uniqueness and screen size all influence use intention and behavior. Hotel organizations must consider these factors when deciding on a specific wearable device to introduce for housekeeper use, with the knowledge that all wearable devices will not be perceived, nor adopted, in the same way when considering their wearability and aesthetics.

Table 1.
OSHA Safety hazards, user requirements, wearable device functions, safety and health outcomes, and practical implications

OSHA Hazard(s)	Housekeeper/User Requirements	Wearable Device Functions	Sensor Type	Safety and Health Outcomes
Safety Hazards (Including violent event(s) and sexual assault)	<p>Calling for assistance and facilitating easy/quick communication during a violent encounter</p> <p>Communicating to supervisors privately regarding incidents of sexual harassment and assault (particularly employee-employee events)</p> <p>Locating a housekeeper once an emergency alert has been deployed</p> <p>Recognizing when a housekeeper has failed to change location over extended period of time</p> <p>Identifying when a housekeeper is experiencing distress and may be in an unsafe situation</p>	<p>Emergency alerts and communication (delivering messages between housekeepers and manages/security)</p> <p><i>Wearable communicators; Alert system wearable; Smartwatches (wrist-worn sensors)</i></p> <p>Location tracking (position and movement)</p> <p><i>Location sensors; Smartwatches (wrist-worn sensors)</i></p> <p>Distress recognition- electrodermal activity (EDA) and heart rate variability</p> <p><i>Physiological sensors (EDA, skin-response measurement sensors); Smartwatches (wrist-worn sensors)</i></p>	<p>Emergency alerts and communication (delivering messages between housekeepers and manages/security)</p> <p><i>Wearable communicators; Alert system wearable; Smartwatches (wrist-worn sensors)</i></p> <p>Location tracking (position and movement)</p> <p><i>Location sensors; Smartwatches (wrist-worn sensors)</i></p> <p>Distress recognition- electrodermal activity (EDA) and heart rate variability</p> <p><i>Physiological sensors (EDA, skin-response measurement sensors); Smartwatches (wrist-worn sensors)</i></p>	<p>Faster emergency response times and quicker deployment of assistance</p> <p>Increased communication during emergencies (real-time messaging between housekeepers and supervisors/security)</p> <p>Greater identification and control of sexual harassment events</p> <p>Faster emergency response times and faster location of housekeeper during a violent or emergency situation</p> <p>Identification of physiological indicators of distress</p> <p>Decreased emergency response time (in situations where housekeepers are unable to call for assistance)</p> <p>Lower incidents of sexual assault and violence</p>
<i>Practical Implications</i>	<ol style="list-style-type: none"> 1. Provide wearable devices to hotel housekeepers to facilitate communication and location tracking during safety emergencies. 2. When selecting wearable devices for adoption, select devices that possess communication, emergency response, and location tracking capabilities. Also, consider how the specific device selected will fit and communicate with existing emergency response procedures, technologies, and platforms. 3. Incorporate wearable devices into safety training, focused on teaching housekeepers best practices for responding to safety emergencies. 			

OSHA Hazard(s)	Housekeeper/User Requirements	Wearable Device Functions	Sensor Type	Safety and Health Outcomes
Chemical, Physical, and Biological Hazards	<p>Detecting chemical or gas hazards</p> <p>Detecting awkward postures (lifting, bending) to provide corrective feedback</p> <p>Detecting falls and identification of risks related to falling incidents</p> <p>Lifting heavy objects (e.g., beds, furniture) and maintenance of good body posture while cleaning</p> <p>Calling for assistance following an accident/injury or hazard exposure</p> <p>Communicating with supervisors regarding potential hazards and exposures</p> <p>Identification for when a housekeeper is experiencing distress and may have experienced an accident/injury</p> <p>Locating a housekeeper once an emergency alert has been deployed, following an accident or injury</p> <p>Recognizing when a housekeeper has failed to change location over extended period of time (due to an accident/injury)</p>	<p>Environmental sensing- chemical/gas</p> <p><i>Chemical sensor or gas sensors</i></p> <p>Activity recognition- motion, gesture, and posture detection</p> <p><i>Kinematic- measurement sensors; Wearable inertial measurement unit (IMU)</i></p> <p>Activity recognition- fall detection</p> <p><i>Fall detection sensors; Wearable inertial measurement unit (IMU); Electromyography sensors</i></p> <p>Physical assistance- posture control and lifting</p> <p><i>External wearable devices (e.g. exoskeletons)</i></p> <p>Emergency alerts and communication</p> <p><i>Wearable communicators; Alert system wearable; Smartwatches (wrist-worn sensors)</i></p> <p>Distress recognition- electrodermal activity (EDA) and heart rate variability</p> <p><i>Physiological sensors (skin-response measurement sensors)</i></p> <p>Location tracking (position and movement)</p> <p><i>Location sensors; Smartwatches (wrist-worn sensors)</i></p>	<p>Reduced exposure to harmful chemical or gas agents</p> <p>Decreased response time and treatment when exposure is detected</p> <p>Prevention of musculoskeletal disorders and lifting-related injuries</p> <p>Use sensor data to design lifting or related interventions and training</p> <p>Reduction of fall accidents and prevention of related injuries</p> <p>Identification of hazards and risk factors related to housekeeper falls and injuries</p> <p>Reduction of difficulty in lifting heavy objects to improve body posture</p> <p>Prevention of musculoskeletal disorders and physical lifting-related injuries</p> <p>Faster emergency response times and quicker deployment of assistance</p> <p>Identification of potential hazards and high-risk situations before accidents or injuries occur (preventative interventions)</p> <p>Identification of physiological indicators of distress</p> <p>Decrease emergency response time (in situations where housekeepers are unable to call for assistance)</p> <p>Faster emergency response times and faster location of housekeeper following an accident or injury</p>	

(continued)

Table 2. OSHA Chemical, physical and biological hazards, user requirements, wearable device functions, safety and health outcomes, and practical implications

Table 2.

OSHA Hazard(s)	Housekeeper/User Requirements	Wearable Device Functions <i>Sensor Type</i>	Safety and Health Outcomes
<p><i>Practical Implications</i></p> <ol style="list-style-type: none"> 1. Adopt wearable devices to identify/detect a variety of hazards and monitor housekeeper health metrics following an accident, injury, or other health emergency. 2. Identify the hazards and exposures housekeepers most frequently encounter, and adopt wearable devices that possess sensors addressing these health risks. 3. Use wearable technology proactively to identify future health and safety risk, and design interventions to provide feedback that helps prevent future injury and illness. 4. Track the prevalence of hazards, exposures, and accidents over time using wearable sensor data. 	<p>Evaluating the health of a housekeeper following an accident or hazardous exposure</p>	<p>Physiological sensing- heart rate, blood pressure, body temperature <i>Physiological sensors (e.g., PPG, thermistor sensor, pressure sensitive transistor)</i></p>	<p>Monitoring for assistance and early intervention</p>

OSHA Hazard(s)	Housekeeper/User Requirements*	Wearable Device Functions. <i>Sensor Type*</i>	Safety and Health Outcomes
Stress and Fatigue	Monitoring housekeeper stress and prevention of employee burnout through stress management interventions (e.g., lifestyle change programs)	Stress recognition (stress level monitoring); Physiological sensing (e.g., heart rate variability) <i>Physiological sensors (ECG; skin-response measurement sensors)^e</i>	Reduction of housekeeper stress and employee burnout Reduction of negative mental and physical health outcomes associated with chronic stress and burnout Identification of work-related stressors and identify targets for stress management interventions
	Facilitating workplace stress management interventions such as lifestyle change and wearable-based stress management programs ^b Promoting housekeeper health to enhance hotel health and wellness initiatives	Physiological sensing, respiratory and physical activity monitors <i>Physiological sensors in conjunction with external (smartphone app); physiological notifications and mindfulness-based activities^c</i> Well-being monitoring; weight, diet, exercise/physical activity <i>Activity trackers/Pedometer; Smartwatches (wrist-wearable sensors)</i>	Increased individual resilience to the physical effects of stress Enhanced existing organizational health, wellness and stress management programs Improvement of housekeeper health and well-being Reduction of negative health outcomes including obesity and high blood pressure Increased physical activity (work and non-work)
	Assessing physical overexertion and fatigue in housekeepers	Physical workload and fatigue assessment (physiological indicators- heart rate/heart rate variability, blood pressure) <i>Cardiac activity- measurement sensors; Muscle-engagement sensors; Physiological sensors</i>	Reduction of fatigue-related accidents (e.g., falls) and injuries Lowered levels of musculoskeletal disorders and physical strain
	Monitoring employee heat strain and heat-related fatigue and illness Recognizing high heat-stress conditions (i.e., conditions that produce excessive heat strain)	Heat-strain monitoring (physiological indicators-body surface/core temperature; heart rate; physiological strain) <i>Physiological sensors</i> Environmental detection (air temperature/humidity; radiant heat; air flow) <i>Temperature and humidity sensors; Accelerometer</i>	Reduce heat strain and health-related health conditions Identify unsafe working conditions that contribute to heat strain
	Assisting housekeepers in monitoring their emotional states and moods (particularly	Emotion and mood recognition Psychological health monitoring	

(continued)

Table 3. OSHA Hazards/ stress and fatigue, user requirements, wearable device functions, safety and health outcomes, and practical implications

Table 3.

OSHA Hazard(s)	Housekeeper/User Requirements*	Wearable Device Functions Sensor Type*	Safety and Health Outcomes
	for housekeepers with psychological issues such as anxiety and depression)	<i>Physiological sensors using external devices (e.g., smartphones)^d</i>	Better assessment and management of psychological changes in emotion and mood (e.g. tiredness, stress)
	Assisting housekeepers in monitoring and improving their sleep	Sleep monitoring- quality/quantity, sleep patterns <i>Sleep tracking sensors; Smartwatches (wrist-worn sensors)</i>	Improvement of housekeeper sleep and reduction of tiredness Reduction of stress, fatigue and other negative physical and mental health outcomes associated with poor sleep
	Assisting housekeepers in monitoring their activity levels and calorie expenditure (to prevent exhaustion)	Energy (calorie) expenditure <i>Wrist-wearable calorie monitoring system; Physical activity sensors</i>	Improvement of productivity and reduction of accidents related to poor sleep Estimate “calorie burn” and physical activity Prevention of physical exhaustion and fatigue
<i>Practical Implications</i>	<ol style="list-style-type: none"> 1. Incorporate wearables into existing health and wellness initiatives and examine how wearable functions can promote health in new programs (i.e. stress management interventions and lifestyle change programs). 2. Discuss with housekeepers ways to use wearable sensor data to improve their personal health and monitor existing health conditions both at work and at home. 3. Communicate with employees regarding who will have access to their personal information and how this information will be used. Find ways to address related privacy concerns. 		

Notes: *User Requirements” and “Wearable Device Functions/Sensor Type” were adapted from taxonomies of wearable devices and sensors outlined in the following: ^aAlberdi *et al.*, 2016; ^bSomentag and Frese, 2003; Smith *et al.*, 2020; ^cShu *et al.*, 2020; and ^dShubina *et al.*, 2020

OSHA Hazard(s)	Housekeeper/User Requirements	Wearable Device Functions	Sensor Type	Safety and Health Outcomes
COVID-19 and Infectious Disease Considerations	Monitoring housekeeper health through temperature scans and other monitoring methods to identify those who may be ill and capable of transferring their illness to others	Illness recognition (physiological sensing- body temperature, heart rate, blood pressure) <i>Physiological sensors (e.g., PPG, thermistor sensor, pressure sensitive transistor); Smartwatches (wrist-wearable sensors)</i>		Early detection of housekeepers with any emergency symptoms (e.g., fever, trouble breathing) Identifying housekeepers who should take sick leave, seek medical attention and/or self-isolate Slow the spread of COVID-19 and other infectious diseases in the workplace Notification to individuals who have been exposed Identification of employees for COVID-19 (or other medical) testing Slow the spread of COVID-19 and other infectious diseases in the workplace
COVID-19 and Infectious Disease Considerations	Facilitating contact tracing in hotels by tracking employees who have been in close contact with those who may have been exposed	Contact tracing; Location tracking (positive and movement) <i>Wearable-based proximity detection; RSS-based methods*</i>		Early detection of housekeepers with any emergency symptoms (e.g., fever, trouble breathing) Identifying housekeepers who should take sick leave, seek medical attention and/or self-isolate Slow the spread of COVID-19 and other infectious diseases in the workplace
COVID-19 and Infectious Disease Considerations	Monitoring housekeeper health through temperature scans and other monitoring methods to identify those who may be ill and capable of transferring their illness to others	Illness recognition (physiological sensing- body temperature, heart rate, blood pressure) <i>Physiological sensors (e.g., PPG, thermistor sensor, pressure sensitive transistor); Smartwatches (wrist-wearable sensors)</i>		Early detection of housekeepers with any emergency symptoms (e.g., fever, trouble breathing) Identifying housekeepers who should take sick leave, seek medical attention and/or self-isolate Slow the spread of COVID-19 and other infectious diseases in the workplace
	Facilitating contact tracing in hotels by tracking employees who have been in close contact with those who may have been exposed	Contact tracing; Location tracking (positive and movement) <i>Wearable-based proximity detection; RSS-based methods*</i>		Notification to individuals who have been exposed Identification of employees for COVID-19 (or other medical) testing Slow the spread of COVID-19 and other infectious diseases in the workplace
<i>Practical Implications</i>				<ol style="list-style-type: none"> 1. Establish clear procedures on how wearable devices can enhance existing COVID-19 policies. 2. Adopt wearable technology with existing contract tracing functions which can be easily altered to include this technology. 3. Address hotel housekeeper concerns or questions regarding contact tracing. Discuss with staff how the data from wearable devices can be an integral tool for preventing the spread of COVID-19 in hotels.

Notes: “Wearable Device Functions/Sensor Type” adapted from [Shubina et al. \(2020\)](#)

Table 4.
OSHA Hazards/
infectious diseases,
user requirements,
wearable device
functions, safety and
health outcomes, and
practical implications

Personal privacy concerns

Technology privacy is broadly defined as the extent to which users control, transfer, and exchange their own personal information (Shin, 2010), in addition to having an awareness about the unwelcome disclosure of personal information to unknown or prohibited entities (Sergueeva and Shaw, 2016). In the context of housekeeper wearables, it may be viewed as a privacy risk if employees possess concerns regarding supervisor or co-worker access to their personal information, physiological status, location, or have more general anxieties concerning data security and encryption (Choi *et al.*, 2017). Information and location privacy become particularly important in circumstances where individuals perceive that the disclosure of their information could potentially cause them social harm (Buenaflor and Kim, 2012), especially when organizational trust is low (Li *et al.*, 2016). Prior research has demonstrated that perceived privacy concerns significantly affect wearable device adoption intention and use, such that perceived privacy risk is found to negatively impact satisfaction with, and intention to, adopt health-care wearable devices (Gao *et al.*, 2015). Thus, housekeeper concerns regarding privacy risks and personal information security may present a significant challenge for hospitality organizations seeking to adopt wearable devices. Given these potential obstacles, hotel organizations must consider ways to mitigate these effects through training initiatives and encourage housekeeper use in spite of these perceived risks to privacy.

Previous wearable technology studies have used privacy calculus theories and the personalization-privacy paradox (Sutanto *et al.*, 2013) to explain how risk-benefit analyses and the perceived value of technology use are salient factors influencing individual adoption of wearable devices (Gao *et al.*, 2015; Li *et al.*, 2016). From this perspective, individuals weigh the perceived benefits of using a wearable against the potential risks and adopt technology where these benefits clearly outweigh perceived risks. This indicates that employees are willing to risk their privacy and location data, but only in contexts where technology is anticipated to grant greater benefits to its users. Alternatively, concerns regarding privacy may negatively impact a worker's perception toward the value of a wearable technology, even in recognition of the potential benefits such that this risk-benefit tradeoff may be important when dealing with technology that possesses clear functional benefits (Choi *et al.*, 2017). Hotel organizations may then encourage housekeeper wearable use by describing the many potential personal safety and health benefits of using a wearable device by describing how the functions can help in an emergency in such a way that the advantages of adoption exceed the perceptions of potential privacy risks. Additionally, organizations should minimize employee privacy concerns by taking transparent steps to limit non-essential access to wearable-collected data and communicating how health data will be accumulated, stored and used. Employees with specific knowledge as to how their personal information will be used and how unauthorized access to their data will be prevented should form more favorable perceptions of privacy with fewer concerns regarding wearable use (Marakhimov and Joo, 2017). Overall, this indicates that while organizations must account for the potential effects of privacy concerns when encouraging the adoption and use of wearables, they can mitigate employee's privacy concerns by reducing perceived privacy risks and clearly communicating the technological benefits to hospitality employees, supervisors, and staff.

Return on investment (ROI)

Hotel organizations may be more likely to invest in a low-cost wearable safety solution for housekeepers, illustrated by the abundance of low-tech panic button wearable products on the market. While these solutions are options for those organizations with limited IT budgets, simple antiquated wearable technologies may not demonstrate the extent to which

hotel brands telegraph the seriousness of their commitment to housekeeper safety before stakeholders. Particularly among those hotel housekeepers who own and wear smartwatches, down-grading at work to a panic button to prevent assault may project

- the hotel organization's lack of financial commitment to housekeeper safety; and
- doubt about the reliability or durability of the wearable.

While hoteliers may struggle to include technological upgrades to budgets adversely impacted by the COVID-19 pandemic, employee safety, brand safety, reputation and increased uncertainties in a post-pandemic business environment will command greater investment in risk management to recruit and retain essential hotel workers (Monkman, 2020). Demonstrated by the rate of adoption and use of safety wearables in the health-care and construction management sectors, the hospitality industry is well-poised to integrate more modern and sophisticated cloud-based wearable technologies for housekeeper safety and health, both as a signal of commitment to housekeepers, and for the protection of guests' health as the industry works to regain the public trust during and after the COVID-19 pandemic (Monkman, 2020).

Concerns regarding wearable technology durability and unknown cost-benefit ratios can affect organizations' willingness to invest in this technology (Schall *et al.*, 2018) such that understanding the direct and indirect benefits of wearable use is essential for justifying purchase and adoption. While hospitality organizations may be reluctant to make a large investment in devices perceived as fragile and expensive, the adoption of smartwatches in the construction industry should prove a convincing counterargument (Awolusi *et al.*, 2018).

Typically quantified by insurance cost savings and less absenteeism, targeted employee safety, health, and wellness initiatives have been found to increase worker productivity (Gubler *et al.*, 2018), job satisfaction (Bangwal and Tiwari, 2019), intention to stay, and lower turnover (Ott-Holland *et al.*, 2019). In addition to these benefits, return on investment (ROI) for effective health wellness initiatives can achieve returns up to 6:1 (Berry *et al.*, 2010). One multi-year study from 2013 to 2015 examined wellness program data from a small long-term care company and suggested that the wellness program saved US\$1.585 for every US\$1 invested (Unsal *et al.*, 2020). In a 2016 report by the US Consumer Financial Protection Bureau, employers received an ROI on their wellness programs of US\$3 for every US\$1 spent, while in the same year, a Fortune 100 company's ROI was US\$2.71 for every US\$1 spent on a physical wellness program (Pervaaz and DiLorenzo, 2016). Organizations cannot measure the success of human resources initiatives by soft outcomes alone, and as the data indicates, investment in employee safety, health and wellness also brings financial returns.

Directions for future research

The purpose of this conceptual paper was to present a critical analysis of the literature in the understudied area of hotel housekeeper safety and health through the lens of the TTF model. Borrowing examples from the health-care and construction industries, an interdisciplinary approach provided the impetus to demonstrate a more holistic conceptualization and rationale for the use of wearables for hotel housekeepers' safety and health versus a piecemeal approach of studying singular phenomena in isolation. A stream of literature has begun to emerge regarding employees' use of wearable technology in the hospitality industry that is centered on augmented or virtual reality, or wearable technology-enabled wellness programs that do not account for the numerous ways these devices may impact the safety, health, and wellness of hotel employees (Torres and Zhang, 2021; Wu *et al.*, 2015). The following sections present a research agenda for the adoption and use of wearable technology among hotel housekeepers based on a conceptual adaptation of

the TTF model (Dishaw *et al.*, 2004; Goodhue and Thompson, 1995). Specifically, the research agenda will focus on the relationships between: I. Task Characteristics; II. Technology Characteristics; III. Employee Attitudes; and IV. Use Outcomes (see Figure 1 and Table 5).

Examining wearable task characteristics (I)

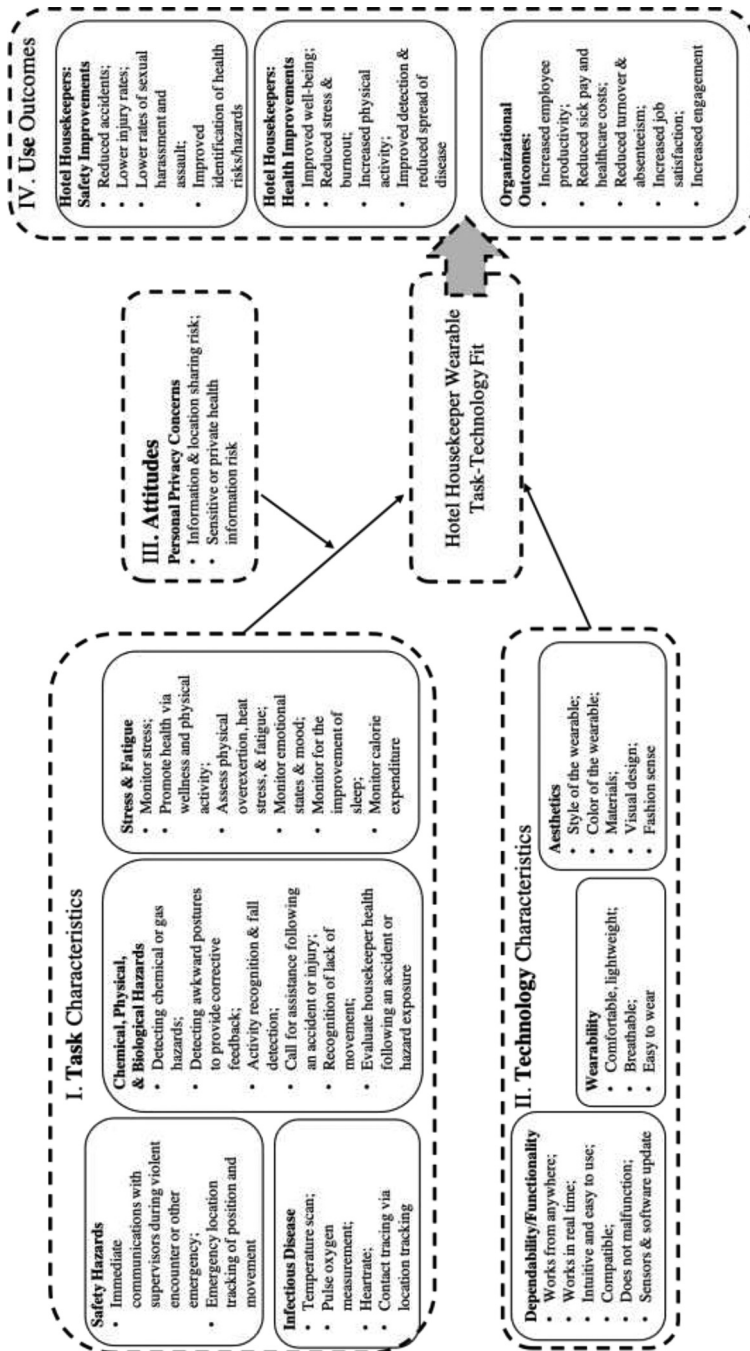
Housekeepers are frequently exposed to a variety of health and safety risks, including:

- safety hazards;
- chemical, biological, and physical hazards;
- stress and fatigue; and
- infectious disease (see Tables 1–4).

To determine the potential of wearables for improved hotel housekeeper and organizational outcomes, it is essential to first specify the task characteristics this technology must address. Understanding that housekeepers are generally vulnerable to violence and other safety threats is of limited practical value without discerning the specific health and safety demands related to these threats, such as a need to communicate effectively and track worker locations during emergencies. Thus, before selecting wearable devices with characteristics well-suited to housekeeper needs, it is essential to identify the major user demands of interest. Although an itemization of potential housekeeper task characteristics are depicted in Figure 1 (see I. Task Characteristics) based on prior literature, it is crucial that future research explores the appropriateness of these items using empirical methodologies.

Future housekeeper wearable research should start by identifying major threats to housekeeper health and safety, along with corresponding task characteristics that can be addressed through technological intervention. Investigating subject matter experts, such as housekeepers and housekeeping supervisors, perceptions of significant threats to health and safety can assist with identifying user demands. Additionally, this process ensures that housekeepers play an active role in wearable adoption strategies, an important aspect of effective intervention development (Nielsen *et al.*, 2010). Task characteristics and housekeeper user demands can be studied with qualitative methods, such as structured interviews or focus groups that will allow researchers to understand how housekeepers experience safety hazards and health risks at work. This can also allow researchers to classify the most pressing health and safety demands that should be addressed through wearable device adoption and use. Participants from a wide range of housekeeper positions and hotel types should be sampled in these studies to determine whether the health and safety needs of housekeepers differ depending on contextual factors such as the size, location, and organizational structure of the hotel. Additionally, data should be collected from many types of housekeepers, particularly those who are high-risk due to factors such as immigration status and socio-economic background, to determine any differences in technology demands. Follow-up quantitative studies, where participants rank or rate the importance of identified task characteristics, would also be valuable for determining the most critical demands for researchers and hotels to address.

Finally, once research has identified important housekeeper health and safety demands, additional studies may be needed to more specifically define these task characteristics. For example, we have identified “immediate communication with supervisor during a violent encounter” and “call for assistance during an accident or injury” as potentially important task characteristics related to safety hazards and chemical, biological, and physical hazards.



Source: Dishaw *et al.* (2004) and Goodhue and Thompson (1995)

Figure 1. Conceptual model of posited relationships between task and technology characteristics, attitudes, TTF and use outcomes of wearable technology among hotel housekeepers.

TTF Construct(s) and Directions for Future Research	Methods, Sampling, and Other Considerations
<p>I. Task Characteristics</p> <ul style="list-style-type: none"> • Explore the use of wearables for seamless communication and location tracking to prevent/mitigate vulnerability to violence and other safety threats; • Inclusion of hotel housekeeper inputs for successful adoption and use of wearable technology and effective intervention development <p>II. Technology Characteristics</p> <ul style="list-style-type: none"> • Focused research on wearable technology characteristics (comfort, design, aesthetics) specifically targeting hotel housekeeper employees' perceptions as it relates to safety and health <p>III. Attitudes</p> <ul style="list-style-type: none"> • Acceptance and use of wearable technology relative to perceptions of data privacy in the consumer and employee contexts; • Exploration of attitudes as a predictor or moderator of TTF 	<ul style="list-style-type: none"> • Mixed methodologies along multiple stakeholders and organizational strata; • Derive a sampling frame from a wide range of hotel service levels and housekeeping positions; • Ensure an inclusive sampling recruitment strategy; • Follow-up studies to measure the success of the interventions and the reliability of the wearable technology • Potential wearable characteristics worthy of investigation include dependability features, intuitive navigation, compatibility, and aesthetic features (e.g., color, style); • Suitable for experimental designs and mixed methods, including focus groups to extract rich data; • Opportunity for big data research due to the miniaturization of sensors; • Sensor dependability should be tested among very large and diverse samples, across a variety of devices and cultural contexts, and in longitudinal studies; • Potential to include other technology acceptance models, such as UTAUT, which address facilitating conditions within an organization • Interventionist research designs testing ethical frameworks for the adoption and use of wearable technology in the workplace; • Exploration of the social-technical gap, which examines the limitations of sensor technologies in reference to how wearable innovations were initially conceived; • Examination of the zone of tolerance for inaccurate data generated by wearables; • Quantitative methods to determine if attitudes predict TTF, or if they moderate the relationship between task and/or technology characteristics and TTF

Table 5.
Summary of
directions for future
research: Hotel
housekeeper safety
and health and Task-
TTF

(continued)

Table 5.

TTF Construct(s) and Directions for Future Research	Methods, Sampling, and Other Considerations
<p>IV. TTF and Use Outcomes</p> <ul style="list-style-type: none"> • Argument for the unique advantages that wearable technologies possess, tested through interventionist strategies; • Determine how wearable solutions impact other types of line-level hotel employees, such as food and beverage workers and front desk attendants 	<ul style="list-style-type: none"> • Empirical studies designed to test the extent to which wearable technologies fulfill hotel housekeeper health and safety demands; • Quantitative methods to determine the overall fit of the TTF model via SEM to target opportunities for training interventions; • Inclusion of the organization's adoption and use outcomes through the technology-organization-environment (TOE) framework; • Combine organizational performance data with wearable adoption and use findings to build the ROI case; • Experimental and quasi-experimental methodologies would be advisable to compare the health and safety effects of available technologies, such as smartwatches, mobile solutions, and panic buttons, against control groups

However, this does not address the more complicated issue of what specifically this communication should look like, whether verbal or text communication are more effective, or what information should be communicated to create the most operative emergency message. Similarly, the ability to assess physiological metrics, including temperature and blood pressure, could be useful for preventing the spread COVID-19 in the short-term or other infectious diseases among employees in the long-term. Determining how this information needs to be calculated, collected, and used is essential for identifying the specific types of wearable sensors that can meet these demands. Overall, to research the effectiveness of wearable technology interventions on housekeeper health and safety, it is essential to identify and clearly define the task characteristics that must be matched with wearables to establish good TTF.

Examining wearable technology characteristics (II)

The proliferation of wearable technologies to enhance consumer experiences in the hospitality and tourism industry has launched a growing body of consumer behavior and marketing research in the discipline. For example, wearable devices supporting augmented reality and virtual reality are under investigation as tourism destinations devastated by the effects of COVID-19 are increasingly reliant on this technology to communicate their products and services through interactivity, immersion, and visualization (tom Dieck *et al.*, 2018; Yung *et al.*, 2020). Recent anecdotal reports have presented the use of smartwatches installed with proprietary software, enabling hotel employee communication through cloud-based or IoT hyper-connectivity (Mercan *et al.*, 2020). While wearable technology adoption research targeting both consumers and employees in the hospitality discipline promotes the service delivery perspective, research with a focus on wearable technology characteristics in the employee safety and health context still lags behind.

One identified gap the research should examine more closely is hotel housekeepers' perceptions of wearable technology dependability/functionality, wearability and aesthetics, as these factors are central to those technology characteristics predicting wearable TTF and ultimately, use (see item II. Technology Characteristics, [Figure 1](#)). Potential wearable technology characteristics worthy of investigation include dependability features, intuitive navigation, and compatibility. These characteristics should all undergo experimental design testing with a variety of types of wearables that vary on these characteristics. Mixed methodologies with interviews and focus groups could also extract rich data to pinpoint potential barriers to future wearable use. Wearable research is uniquely positioned to collect large amounts of data due to sensor miniaturization. Sensor dependability could be tested among very large and diverse samples, which could be replicated across a variety of devices, cultural contexts, and in longitudinal studies.

Future wearable technology research for use among hotel housekeepers or other essential line-level hospitality workers should investigate alternative characteristics such as wearability and aesthetics. Here again, multiple wearable devices that differ in wearability and aesthetics could be tested by experimental means and across large subsets of users who would assess wearable device comfort, breathability, style, color, and visual design. Large sample designs could empirically test users' perceptions of wearability and aesthetics before, during, and after use, supported by the TTF or other technology acceptance models based on individual adoption. After investigating hotel housekeeper wearable technology characteristics and preferences in isolation, future research could align the technology characteristics with task characteristics and constructs toward a more holistic test of the larger TTF model (see [Figure 1](#)), and perhaps in combination with the Unified Theory of Acceptance and Use of Technology (UTAUT) ([Venkatesh et al., 2003](#)). The inclusion of UTAUT would expand the model to address facilitating conditions, or the extent to which an organization will support and promote the use of a robust and well-designed wearable technology.

Attitudes and privacy data (III)

There is evidence which suggests that while employees generally appreciate that employers care about their safety, health, wellness and working conditions, they also have valid concerns about privacy and personal data disclosure of their tracked information ([Chung et al., 2017](#)). This is in contrast to the rate at which consumers either knowingly or unknowingly share privacy information via smartwatches and fitness trackers in the consumer marketplace. For example, in a Pew Research Center survey conducted in June 2019, nearly one in five adults in the USA regularly wore a smartwatch or fitness tracker ([Vogels, 2020](#)), illustrating widespread adoption and use of wearables among consumers. Motivations driving the adoption and use of smartwatches and fitness trackers in employees' personal lives vary, but in the workplace, motivations are more prominent, as several incentive structures have been leveraged to include the use of virtual points and gift cards, and discounts on insurance premiums for using an organization-issued wearable device at work ([Chung et al., 2017](#)). These and other practices for adoption should be explored in the context of personal attitudes and concerns around data privacy while using wearables in the workplace. Comparison studies should investigate if the benefits consumers garner from wearable use extend into the work context, and if those additional work-related benefits and incentive structures outweigh the perceived risks related to personal privacy. Finally, intervention research designs in this area could implement and test the effectiveness of an integrated ethical framework for preventing the adverse effects of a wearable technology adoption initiative. Developed by [Wright and Schultz \(2018\)](#), an

ethical framework based on stakeholder theory and the social contract emphasizes four steps for the incorporation of a technology seemingly positioned to collect personal data, including:

- The identification of stakeholders impacted by the company's actions.
- The enumerations of the existing social contracts.
- Assessing the stakeholder impacts of the new technology.
- Purposefully minimizing the violations or disruptions to the stakeholders expectations.

Future research on the adoption of wearables among hotel housekeepers could use this framework when introducing and launching the technology and then test employee satisfaction, engagement, turnover intention and organizational commitment.

Research based on human-computer interaction posits that there are limitations to technology when measuring highly nuanced and contextualized human activity, deemed the "social-technical gap". [Ackerman \(2000\)](#) defined this gap as "the divide between what we know we must support socially and what we can support technically" (p. 180). As human sensor technology has evolved, researchers have revealed the limitations of sensors available on the market, compared with what was theoretically possible to measure at the time. Depending on the context and the development of a technological innovation, the accuracy of data extrapolation from the algorithms generated by sensors may not be highly accurate nor usable, especially in a workplace when movements are constrained to job tasks or limited in other ways based on the confines of the work environment ([Ackerman, 2000](#); [Chung et al., 2017](#)). Furthermore, clinical researchers have reported inconsistencies with the reliability and validity of patient-generated health data (PGHD) in the health-care context, with concerns about the majority of wearable manufacturers who have not presented empirical evidence as to the effectiveness of such devices ([Piwiek et al., 2016](#); [West et al., 2017](#)). Theoretical development around the zone of tolerance for inaccurate data generated by a wearable would not only serve to benefit modern safety and health innovations in the hospitality industry, but it would also be a major contribution to the body of literature on PGHD in the parallel service-based health-care context that is also confronted with data privacy concerns ([Lai et al., 2017](#)).

Finally, future research designed to determine the role of attitudes and privacy concerns of hotel housekeepers as a result of using wearable devices at work should test if attitudes are a predictor of TTF, or a moderator of the relationship between task characteristics and TTF, as depicted in the conceptual model (see III. Attitudes, [Figure 1](#)). Seminal research in this area has demonstrated that when TTF constructs are integrated with Technology Acceptance Model (TAM) constructs, where attitudes remain a predictor of intention to use on the TAM side of the model, the integration of TTF and TAM explains a higher variance of the dependent variable (utilization) than the two models independently ([Dishaw and Strong, 1999](#)). Using the TTF model alone, the role of attitudes or 'individual characteristics' has been posited to predict TTF and use directly and simultaneously, and moderate the relationships between task characteristics and fit and/or technology characteristics and fit ([Dishaw et al., 2004](#)). Future theoretical development of the role that privacy concerns play in the TTF model regarding the use of wearables for safety and health on the job would be useful to determine points of potential interventions. Mitigating privacy concerns through training and communication is optimal in advance of adoption, however lessons learned through large scale studies addressing concerns over private health and location

information would be desirable prior to implementing the initiative more broadly across the hospitality industry.

Task-Technology fit and use outcomes (IV)

Finally, it is essential to empirically test the extent to which wearable device functions and other technology characteristics fulfill necessary housekeeper health and safety demands, as well as potential individual and organizational use outcomes (see IV. Use Outcomes, [Figure 1](#)). Our argument that wearables should be used in technology interventions for housekeeper health risks and safety hazards is built on the assumption that wearable devices possess characteristics that make them better equipped to meet these demands and that this technology can do so more effectively than alternative technologies. It is essential to provide evidence of the fit between housekeeper health and safety-related task characteristics and wearable technology characteristics to justify adoption because this indicates that wearable technology possesses the functions and characteristics necessary to fulfill housekeepers' needs. Once fit has been established, it is also important to study whether TTF predicts actual wearable use or more specifically, whether better TTF predicts greater use of wearable technology among housekeepers. Although not explicitly outlined in our conceptual model, this research should also work toward identifying potential moderating factors that may influence the relationship between fit and use. These could include privacy concerns, workload, or supervisor support, which may positively or negatively influence hotel employees' likelihood of using wearable devices, regardless of the levels of TTF. Both the fit and use of wearable technology should be studied in future hospitality research, with a specific focus on longitudinal research that tracks the relationship between these constructs over time. Future research in this area should emanate from a combined technological and organizational structural approach of wearable adoption by hotel employees ([Gonzalez et al., 2020](#)), so as to garner a better understanding of the factors facilitating and impeding wearable device fit, adoption and use for employee safety and health.

This line of research can also bolster the ROI case for wearable technology by assessing the organizational outcomes of use and measuring the direct and indirect costs and benefits of adoption. Outcome focused studies can fill an existing research gap by focusing on important housekeeper health and safety outcomes that are often understudied in the hospitality literature, including incidents of sexual harassment and assault, and accidents and injury rates (see IV. Use Outcomes, [Figure 1](#)). Future wearable research should explore the safety and health impact of different types of wearable devices that vary in their form and function, and compare these devices across a variety of available safety technologies to justify their adoption against costs. Experimental and quasi-experimental methodologies would be advisable to compare the health and safety effects of available technologies, such as smartwatches, mobile solutions, and panic buttons, against control groups. Studying the combined effects of multiple technologies could also reveal whether the positive effects of wearables are more significant when the technology is used alone or in concert with other devices. Alternatively, qualitative studies, including structured interviews or focus groups, would be desirable for exploring additional factors with the potential to impact wearable adoption and use. Although the focus of this paper was on housekeepers, wearable solutions should also provide benefits to many types of line-level hotel employees, such as food and beverage employees and front desk attendants. These benefits warrant further exploration, both as focused studies and as longitudinal designs.

The purpose of a workplace health and wellness program is to improve employee health and well-being, with an added benefit of employee retention and organizational satisfaction.

Originally focusing on minimizing health-care and insurance expenditures, organizations have also used workplace wellness programs for safety and associated preventative interventions (Christophersen *et al.*, 2015). An organization may have the best intentions in implementing a workplace health and wellness program, but too often little attention is paid to a more comprehensive view of total worker health (Solnet *et al.*, 2020) and the program is relegated to focusing on what is both easy and reliable to track, such as step counts (Chung *et al.*, 2017; Song and Baicker, 2019). The hospitality industry has taken a similar limited approach to step counting as a proxy for employee health and wellness management (Solnet *et al.*, 2020; Torres and Zhang, 2021), demonstrating a lack of a deeper commitment to employees' real concerns and expectations from a workplace health and wellness program. Hospitality-centered research in this area has also revealed employees' expectations of a workplace health and wellness program that extends beyond step counts to include nutrition awareness, smoking cessation, stress management, and exercise programs as priorities over tracking devices (Zhang *et al.*, 2020).

Using theoretical, behavioral, and structural frameworks from occupational health psychology as it pertains to Total Worker Health (Centers for Disease Control and Prevention, 2020 [CDC]), there is an opportunity to advance a more holistic theoretical framework of worker health in the hospitality discipline based on a humanistic and agentic perspective, rather than a fiscal perspective (Solnet *et al.*, 2020). NIOSH's Total Worker Health approach focuses on the integration of safety and health hazards protections together with injury and illness prevention, thus advancing worker health, safety, and well-being through interventions that target a variety of risk factors in the workplace (CDC, 2020). This highlights the importance of not addressing health, safety, and wellness issues in isolation but rather recognizing their interrelatedness and ability to affect one another. Due to the potential for hazards and exposures to compound the negative health and safety effects of each, wearable hospitality research can greatly enhance its reach and impact by researching wearable devices in studies that consider multiple sources of hazards or exposures and potential outcomes simultaneously, to better account for their connected effects. Additionally, wearable technology should be integrated with existing health and safety initiatives, such as those that focus on addressing conditions of work, to test the effectiveness of wearables in complex multi-faceted intervention programs. Due to their essential nature, worker safety and health monitoring of hotel housekeepers is uniquely suited for the development and testing of a holistic health and wellness framework, which addresses health and safety issues simultaneously, to improve hotel housekeeper workplace health, safety and wellness during and after COVID-19.

Conclusion

The purpose of this conceptual paper was to promote the case for the use of wearable devices among hotel housekeepers as an industry-wide intervention for both housekeeper safety and health, and by extension, the safety and health of hotel stakeholders. Particularly in the age of COVID-19 and beyond, the adoption and use of wearable devices for housekeeper safety and health should be on the forefront of practical investigation and theoretical development. Posited in this paper was also the utilization of an interventionist approach to the study of wearable adoption, which set forth a research agenda for a holistic interdisciplinary framework for wearable research in the hospitality discipline. This paper significantly expands upon prior wearable literature in which the research has tended to focus on singular topics in isolation or on customer-facing use. Using the TTF model, the characteristics and functionalities of wearable technology were examined in terms of matching the safety and health-related demands of housekeepers, with examples from the health and construction industries supporting adoption and use in a variety of contexts.

While much of the hospitality industry remains reluctant to adopt new technologies compared with other industries (Hahn, 2020; Herz, 2020; Schaap, 2019), the impetus for a wearable safety and health solution is an argument exacerbated by the safety and health concerns brought on by COVID-19 (McCartney and McCartney, 2020). In order for the hospitality industry to return to full economic viability, consumer safety and health, and ultimately confidence, must be restored. In addition to the massive efforts that will be required among all stakeholders (marketing, human resources, facilities management, investors, brand equity, etc.) to stabilize the hospitality industry, a great deal of labor will be required of essential line-level hotel housekeepers. Without careful consideration of hotel housekeepers' longevity as key human capital worthy of investment, their crucial roles will be undermined in the efforts to entice the return of hotel guests via marketing efforts alone.

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