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Ways in which healthcare interior environments are associated with perceived safety against infectious diseases and coping behaviours

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SUMMARY

Background: Global pandemic outbreaks are a cause of fear. Healthcare workers (HCWs), especially those fighting the pathogens at the front line, are at higher risk of being infected while they treat patients. In addition, various environmental fomites in hospitals, which may carry infectious agents, can increase the risk of acquiring an infectious disease.
Aim: In order to deliver the best healthcare practice, it is critical that HCWs feel safe and protected against infectious diseases. The aim of this study was to improve understanding of HCWs' hand hygiene (HH) behaviours and perceptions of infectious diseases from a psychological perspective.
Methods: Environmental features were observed in three departments, and questionnaires were used to determine perceived safety against infectious diseases among HCWs and the coping behaviours they used (e.g. avoidance and disinfection).
Findings: This study found that an increase in the number of HH stations at convenient locations would increase HH compliance and perceived safety against infectious diseases among HCWs. In response to the current research gap in psychological aspects associated with HH, this study found that HCWs' coping behaviours can be predicted by their perceived likelihood of contamination and perceived vulnerability.
Conclusions: The study findings should be interpreted with care, and further studies with more academic rigor are needed.

Introduction

Continuous outbreaks of infectious diseases, from severe acute respiratory syndrome to the COVID-19 pandemic, have awakened fear in the global population. Specifically, healthcare-associated infections (HAIs) — one of the leading causes of morbidity and mortality worldwide — have received a great deal of attention from researchers [1,2]. To reduce HAIs, hand hygiene (HH) (i.e. washing one's hands with soap and water or disinfecting one's hands with an alcohol-based antiseptic agent [2]) is the simplest, most effective, cost-efficient and universally applicable preventive measure [3,4].

Unfortunately, despite its simplicity and benefits, low HH compliance rates among healthcare workers (HCWs) are common, ranging from 5% to 81% with an average of 40% [5]. Various causes and barriers explaining the low HH compliance rate have been identified [5–7]. The key barriers are environmental features (e.g. not user-friendly or non-intuitive facilities, and low accessibility and visibility of HH stations) and personal features (e.g. forgetfulness and time constraints) [8,9].

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To overcome the environmental barriers, diverse and mainly multi-faceted interventions have been introduced [10,11], and the ideal locations of HH stations have been tested [12]. Based on associated work flows [13], the most desirable locations for HH stations are near to room entrances and within arm's reach of patients [12]. When more HH stations are available, higher HH compliance rates have been reported [14,15]; however, not all studies found the same results [16,17]. Furthermore, it remains unclear how different environmental features (e.g. number of HH stations) are associated with perceived safety against infectious diseases, although HCWs acknowledge that HH can prevent the spread of infectious diseases and environmental features can affect HCWs' compliance with HH [18].

Hospitals have various inanimate objects ('fomites') which carry infectious agents, such as doors, furniture and sink taps [19]. Healthcare-associated pathogens are transmitted through direct person-to-person contacts (e.g. droplets) and indirect contacts (e.g. environmental fomites) [1]. Both porous surfaces (e.g. curtains) and non-porous surfaces (e.g. bedrails and medical equipment) can be contaminated [20], and pathogens can live in the environment for hours, days, weeks or months depending on the micro-organism [21]. Patients are at high risk of acquiring HAIs, particularly due to their vulnerability, and HCWs are exposed to the same risk [22] as they share the environment with patients and the same pathogens may cause infections through the contamination of environmental surfaces [21]. To cope with the fear of contamination, people develop coping behaviours, such as isolating their hands and using other body parts (e.g. feet, elbows, back) to open doors, and frequently disinfecting their hands or environmental surfaces [23]. Previous, but very limited, studies have investigated how personal belief [24,25], disgust propensity [26] and health anxiety [27] are related to avoidance tasks.

As the body of knowledge implies, HH is a complex behaviour involving multiple psychological processes. This may be the main reason for low HH compliance rates, despite myriad attempts to increase them. Unlike the widely studied behavioural aspects influencing HH, a research gap regarding the psychological aspects still exists [28].

Recognizing the gaps in the literature, this study was developed to explore: (1) associations between environmental features and perceived safety against infectious diseases; and (2) associations between perceived contamination and coping behaviours among HCWs. In this way, this study aimed to improve understanding of HCWs' HH behaviours and perceptions of infectious diseases.

Methods

Setting and population

Three departments at a university hospital in the USA — intensive care unit (ICU), paediatric emergency room (ER) and internal medicine outpatients (OP) — participated in the study. HCWs (e.g. doctors, nurses, residents, etc.) working in these departments were recruited.

Study design

To explore how interior environments are associated with perceived safety against infectious diseases and coping behaviours among HCWs, a mixed-method design consisting of observations and questionnaires was applied. In the observations, data were collected regarding environmental features. The questionnaires were conducted to measure participants' perceived safety and their behaviours.

Observations

Observations were conducted regarding environmental features [i.e. number of HH stations, number of items of shared medical equipment (SME), traffic volume] in the three departments. Each department was observed for 90 min on five randomly selected days and times. Before the initial observation, the numbers of HH stations and SME (e.g. computer, mouse, keyboard, phone, thermometer, blood pressure equipment) were counted. HH stations included foam/gel sanitizers and sinks with hand soap. The HH ratio was calculated for each department by dividing the total number of HH stations by the mean number of HCWs in each department, and the SME ratio was calculated for each department by dividing the total number of SME by the mean number of HCWs. The numbers of people who occupied the space were counted at the beginning and end of the observations to calculate the mean number of people in the space. Over the five observations, the numbers of people who left or entered the space were also counted. Finally, traffic volumes were measured by dividing the sum of the mean number of people going into and coming out of the space by the mean number of people in the space.

Table I summarizes the environmental features for each department. The ICU had a medium HH ratio, a low SME ratio and high traffic volume. The ER had high HH and SME ratios but low traffic volume. OP had a low HH ratio, a high SME ratio and high traffic volume.

Questionnaires

Paper questionnaires were distributed. In total, 104 HCWs from the three departments (ICU=26, ER=24, OP=54) completed the questionnaires. Table I summarizes the participants' demographic information. The participants were asked to report: the degree of their perceived safety against infectious diseases at work (α=0.92) and perceived vulnerability on the seven-point Likert scale (strongly disagree to strongly agree); the likelihood of a physical object being contaminated and causing infection (α=0.94) on the 0–100 scale (not at all to extremely likely); their behaviours (α=0.94) on the five-point Likert scale (never to always); and HH compliance rates among the HCWs themselves. For HH compliance rates, HCWs working in all three departments reported higher compliance rates for themselves compared with their colleagues.

Data analyses

Analysis of variance (ANOVA) was conducted to explore differences in participants' reported perceptions and beliefs between the three departments. Subsequently, Mann–Whitney *U*-tests were used to examine differences in self-reported HH compliance rates between two groups (i.e. participants who perceived the quantity and location of HH stations to be a hindrance and participants who did not perceive the quantity and location of HH stations to be a hindrance). Finally, regression analyses were conducted to find any associations between the perceived likelihood of contamination and coping

Table I
Participants' demographics and the environmental features in the three departments

Participants' demographic information		ICU	ER	OP
		N (%)	*N* (%)	*N* (%)
Gender	Male	19 (73%)	18 (75%)	42 (78%)
	Female	7 (27%)	6 (25%)	12 (22%)
		Mean (SD)	Mean (SD)	Mean (SD)
Age (years)		40.24 (10.12)	37.50 (11.71)	41.58 (12.69)
Practice experience (years)		14.84 (9.81)	14.40 (12.16)	17.08 (12.72)
Environmental features		ICU	ER	OP
Hand hygiene station ratio		111:69=1.71:1	36:15=2.40:1	75:72=1.04:1
Sharing medical equipment ratio		109:69=1.57:1	57:15=3.81:1	270:72=3.75:1
Traffic volume		(68+65)/82=1.62	(11+9)/18=1.11	(82+79)/87=1.85
Hand hygiene compliance rate		ICU	ER	OP
		Mean (SD)	Mean (SD)	Mean (SD)
Participants' rate (%)		87.25 (13.28)	92.00 (8.22)	85.26 (13.75)
Colleagues' rate (%)		72.25 (18.11)	83.08 (11.97)	76.38 (21.42)
Perceived vulnerability		2.52 (1.44)	3.00 (1.74)	2.48 (1.76)

ICU, intensive care unit; ER, emergency room; OP, internal medicine outpatients; SD, standard deviation.

behaviours, and the effect of perceived vulnerability on the associations. SPSS Version 24 (IBM Corp., Armonk, NY, USA) was used for data analysis.

Ethical approval

This study was approved by the institutional review board. All participants provided written informed consent. All data were analysed and presented anonymously.

Results

Perceived safety against infectious diseases

The participants in all three departments felt safe against infectious diseases in their workplace (see Table II) due to the supportive conditions of the physical environment (e.g. easy-to-clean furniture materials and fomites), sufficient and accessible HH stations, and their compliance with the HH protocol. Further ANOVA analysis indicated that the participants in the three departments perceived their safety differently because of the number and location of HH stations [$F(2,102)=5.47$, $P<0.01$]. Due to equal variances, Tukey's post-hoc test was conducted, and the results implied that the participants working in the ICU and OP perceived that they were less safe than the participants working in the ER. Similarly, the participants working in the ER felt more protected against infectious diseases because HH compliance in their department was higher compared with that of the ICU [$F(2,102)=3.98$, $P<0.05$].

Hand hygiene compliance

The participants reported high HH compliance rates for themselves and their colleagues (see Table I). When asked about the reasons for poor HH compliance or any barriers to appropriate HH compliance, the most common reason was 'not thinking about it/forgetfulness' (65%) followed by 'skin irritation and dryness' (59%), 'too busy/insufficient time' (47%) and 'inconvenient location/shortage of HH stations' (42%) (see Figure 1). ANOVA analyses showed that the participants in the three departments gave different reasons for poor HH compliance. More than 50% of the participants in OP reported that inconvenient locations and a shortage of HH stations hindered their HH compliance, compared with approximately 26% of the participants in the ICU and ER. In contrast, approximately 50% of the participants in the ICU and ER reported that patient care

Table II
Perceived safety from infectious diseases

I feel protected from getting infectious diseases	ICU[a]		ER[b]		OP[c]		χ^2	Post-hoc
	Mean	SD	Mean	SD	Mean	SD		
While working	4.88	1.51	5.54	1.07	5.04	1.44	1.68	
Because of the supportive conditions of the physical environment	4.58	1.77	5.54	1.14	5.13	1.44	2.70	
Because of the sufficient number and accessibility of hand hygiene stations	4.75	1.73	6.08	1.13	5.00	1.68	5.47**	a,c<b
Because I follow the current hygiene protocol	5.88	1.15	6.08	0.93	5.66	1.21	1.22	
Because I believe my colleagues follow the hygiene protocol	4.50	1.32	5.54	1.17	5.00	1.36	3.96*	a<b

ICU, intensive care unit; ER, emergency room; OP, internal medicine outpatients; SD, standard deviation.
*$P<0.05$, **$P<0.01$.

Table III
Association between hand hygiene (HH) compliance rate and number and location of HH stations

	No hindrance due to number and location of HH stations		Hindrance due to number and location of HH stations		ΔMean	*Z*
	Mean	SD	Mean	SD		
HH compliance rate	90.05	9.94	83.65	15.19	6.40	2.58**

SD, standard deviation; ΔMean, difference in mean.
**$P<0.01$.

hindered HH compliance, whereas significantly fewer participants in OP reported this as a barrier.

To understand the association between the HH compliance rate and HH stations, Mann–Whitney U-tests were conducted because the Shapiro–Wilk test indicated non-normality of the data distribution (see Table III). The results implied that the participants who perceived the inconveniently located and insufficient number of HH stations as a barrier to good HH compliance reported a significantly lower HH compliance rate (mean=83.65) than that reported by the participants who did not perceive the location and number of HH stations to be a barrier (mean=90.05).

Contamination cognition and coping behaviours

The participants were asked to indicate the likelihood that eight objects would be contaminated and that touching the objects would cause infection (see Table IV). The participants perceived that all of the objects had higher likelihoods of being contaminated than of causing infection. The results indicated moderate likelihoods, as the majority ranged between 35 and 50 on the 1–100 scale. Based on the ANOVA analyses, the likelihoods that any of the objects of would be contaminated and cause infection did not differ significantly between the three departments.

When the participants were asked about their responding behaviours to the eight objects which might be contaminated and cause infection, their coping behaviours (e.g. disinfecting hands, avoiding touching the objects) differed depending on the object (see Table V). The participants in all three departments washed/disinfected their hands more frequently after using the toilet, touching medical equipment and touching objects in restrooms (e.g. doorknobs, taps), and less frequently carried antibacterial hand sanitizer and tried to avoid touching telephone receivers. ANOVA analyses specified that the reported coping behaviours of participants to disinfect their hands after touching or avoid touching the objects in restrooms, and telephone and elevator buttons differed between the three departments. Tukey post-hoc analysis indicated that participants in the ICU reported disinfecting their hands or avoiding touching the potentially contaminated objects more frequently compared with the participants from the ER and OP.

Individual differences – perceived vulnerability

Regression analyses were conducted to explore whether the perceived likelihood of the eight objects being contaminated and coping behaviours was associated regardless of department. The results indicated that the perceived contamination likelihoods for door handles (Model 1), stairway railings (Model 3) and elevator buttons (Model 5) significantly predicted coping behaviours. The perceived likelihood that door handles would be contaminated was strongly associated with the behaviour to avoid touching door handles [$R^2=0.04$, $F(2,102)=5.33$, $P<0.05$]. Similarly, the perceived likelihoods that stairway railings [$R^2=0.05$, $F(2,102)=6.02$, $P<0.05$] and elevator buttons [$R^2=0.07$, $F(2,102)=8.32$, $P<0.01$] would be contaminated were strongly associated with HH behaviours after touching the objects (See Table VI).

Additional regression analyses (Models 2, 4 and 6) included the perceived vulnerability of the participants to infectious diseases to examine its moderating effects on the associations in Models 1, 3 and 5. The results demonstrated that perceived vulnerability to infectious diseases, as a moderator, strengthened the associations between the contamination likelihoods

Table IV
Perceived likelihoods that eight objects would be contaminated and cause infection

	Perceived likelihood that the object would be contaminated (1–100 scale)							If contaminated, perceived likelihood that touching the object would cause infection (1–100 scale)						
	ICU		ER		OP		χ^2	ICU		ER		OP		χ^2
	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	
Toilet handle	44.6	29.9	58.1	32.1	53.7	30.9	1.19	32.4	25.9	44.4	36.3	41.1	29.7	0.93
Toilet seat	41.5	31.9	56.5	32.5	52.0	32.7	1.33	31.4	27.6	43.2	33.8	43.3	32.2	1.14
Sink tap	40.7	27.9	55.0	32.8	50.9	31.0	1.38	32.9	25.5	41.6	32.9	40.5	28.4	0.63
Door handles	50.0	30.4	57.3	31.9	52.9	30.7	0.34	39.5	24.4	42.2	34.6	43.7	27.3	0.15
Medical equipment	54.6	25.7	56.3	37.4	48.8	30.2	0.57	57.4	29.4	47.8	37.2	39.8	29.0	2.26
Telephone	48.7	26.5	49.2	31.3	50.7	29.9	0.05	39.3	22.9	41.2	33.0	41.5	27.9	0.05
Stairway railings	48.3	26.8	50.6	31.1	46.6	30.6	0.15	39.3	25.7	41.6	33.6	35.3	27.3	0.44
Elevator buttons	47.1	27.7	48.1	32.2	47.1	31.8	0.10	37.8	24.2	40.6	32.4	33.6	26.9	0.55

ICU, intensive care unit; ER, emergency room; OP, internal medicine outpatients; SD, standard deviation.

Table V
Coping behaviours used for objects which might be contaminated and cause infection

Coping behaviours		ICU[a]		ER[b]		OP[c]		χ^2	Post-hoc
		Mean	SD	Mean	SD	Mean	SD		
General	Carrying antibacterial hand sanitizer at all times	1.83	1.31	1.69	1.19	1.98	1.42	0.43	
	Washing/disinfecting hands each time before eating/after eating	4.83	0.38	4.23	0.99	4.11	1.02	5.38**	a>c
Restroom	Washing/disinfecting hands each time after using the toilet	4.92	0.39	4.92	0.28	4.98	0.14	0.75	
	Try to avoid touching toilet lever	4.00	1.32	2.69	1.59	3.37	1.43	5.10**	a>b
	Disinfecting/wiping toilet seat before using it	2.83	1.09	2.42	1.39	2.50	1.36	0.72	
	Try to avoid touching restroom doorknobs and taps	3.88	1.12	2.85	1.52	3.44	1.36	3.72**	a>b
	Washing/disinfecting hands after touching restroom doorknobs and taps	4.42	0.93	3.31	1.59	3.69	1.44	4.72**	a>b
Door handles	Try to avoid touching public door handles	3.29	1.33	2.65	1.50	3.19	1.30	1.73	
	Washing/disinfecting hands after touching public door handles	3.13	1.03	2.38	1.33	2.93	1.43	2.21	
Medical/sharing equipment	Washing/disinfecting hands after using medical/shared equipment	4.46	0.43	4.77	0.78	4.60	0.74	1.28	
Telephone	Trying to avoid touching telephone receivers	2.79	1.38	1.80	1.35	1.80	1.29	5.15**	a,c>b
	Washing/disinfecting hands after touching telephone receivers	3.00	1.06	2.19	1.41	2.07	1.20	4.92**	a>c
	Disinfecting telephone receivers	3.29	1.16	2.73	1.51	2.94	1.37	1.08	
Stairway railings	Try to avoid touching stairway railings	3.61	1.37	2.69	1.64	2.94	1.31	2.77	
	Washing/disinfecting hands after touching stairway railings	3.17	1.37	2.31	1.38	2.48	1.31	2.96	
Elevator buttons	Try to avoid touching elevator buttons	2.96	1.33	2.19	1.63	2.15	1.29	3.03*	a>c
	Washing/disinfecting hands after touching elevator buttons	2.83	1.34	2.12	1.40	2.17	1.27	2.49	

ICU, intensive care unit; ER, emergency room; OP, internal medicine outpatients; SD, standard deviation.
*$P<0.05$, **$P<0.01$.

Table VI
Associations between perceived contamination and coping behaviours, and the moderating effect of vulnerability on the association

Avoid touching – door handles	Model 1			Model 2		
	β	SE *B*	*t*	β	SE *B*	*t*
Contamination likelihoods	4.85*	2.10	2.31	4.57*	2.07	2.21
Individual differences – vulnerability	-	-	-	3.56*	1.74	2.04
Constant	27.51***	7.09	3.88	19.24*	7.93	2.43
F		5.33*			5.18**	
Adjusted R^2		0.04*			0.09**	
Hand hygiene – stairway railings	Model 3			Model 4		
	β	SE *B*	*t*	β	SE *B*	*t*
Contamination likelihoods	5.16**	2.11	2.45	5.14*	2.10	2.44
Individual differences – vulnerability	-	-	-	3.73*	1.74	2.15
Constant	24.42***	6.14	3.99	14.97*	7.08	2.11
F		6.02**			6.33**	
Adjusted R^2		0.05**			0.10**	
Hand hygiene – elevator buttons	Model 5			Model 6		
	β	SE *B*	*t*	β	SE *B*	*t*
Contamination likelihoods	5.62**	1.95	2.88	5.35**	1.92	2.79
Individual differences – vulnerability	-	-	-	3.46*	1.72	2.02
Constant	23.38***	5.28	4.43	15.19*	6.59	2.03
F		8.32**			6.14**	
Adjusted R^2		0.07**			0.11**	

SD, standard deviation.
*$P<0.05$, **$P<0.01$, ***$P<0.001$.

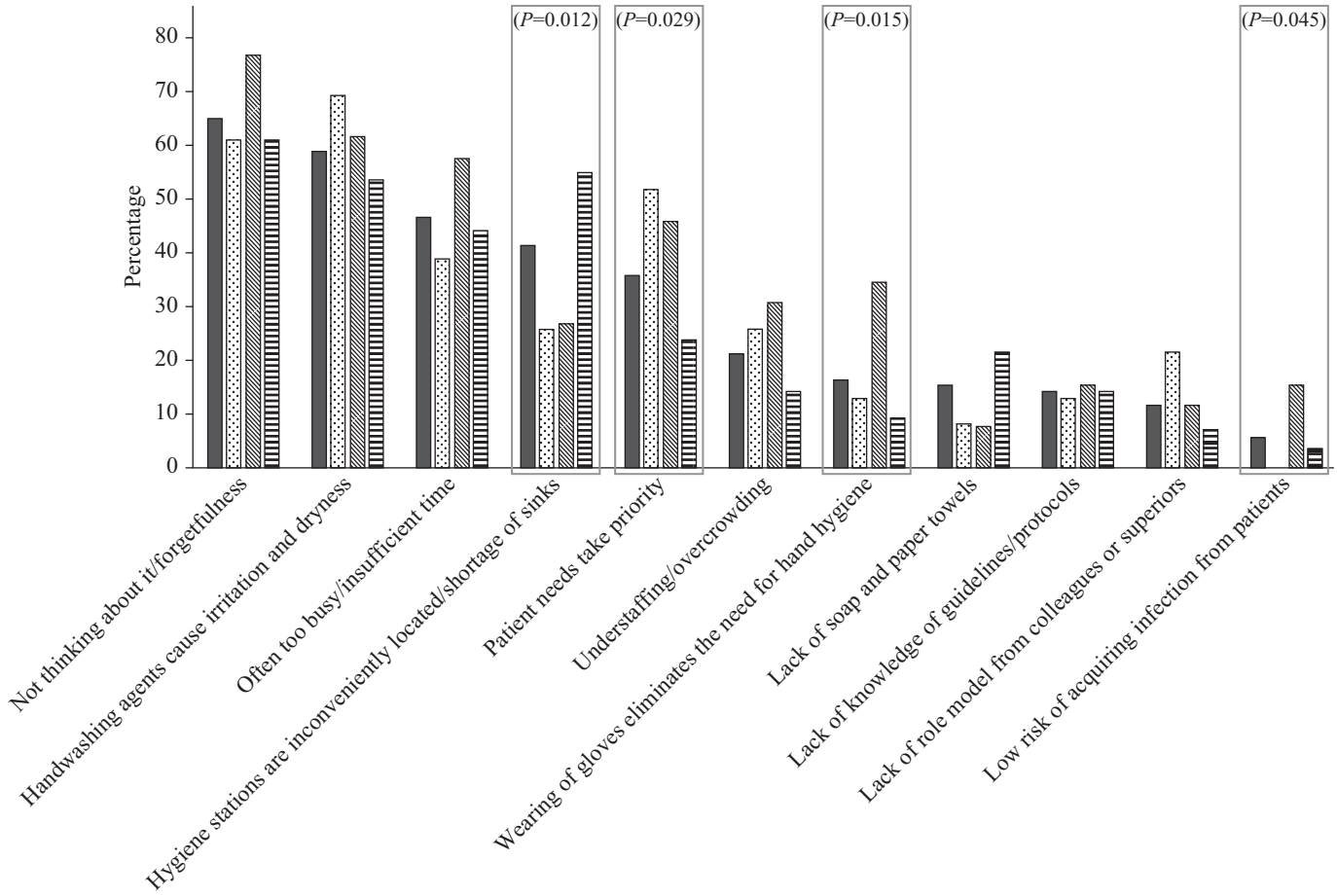

Figure 1. Barriers to appropriate hand hygiene compliance. Boxes indicate the barriers that differed significantly between the three groups. Solid bars, overall; stippled bars, intensive care unit; striped bars, emergency room; open bars, internal medicine outpatients.

of three objects and coping behaviours by explaining more variance through increased adjusted R^2 values. These three associations might imply that the coping behaviours for these three objects would be associated with perceived contamination likelihoods and vulnerability rather than departmental differences.

Discussion

Impact of interior environments

The results suggested that different environmental features, specifically the HH ratio and traffic volume, resulted in differences in perceived safety and HH compliance. The participants working in the ER felt much safer because of a sufficient number and accessible HH stations (see Table II). This result may be because the ER had a higher HH ratio but a lower traffic volume than the ICU and OP (see Table I).

Previous literature has investigated perceived safety and HH compliance. Paediatric residents reported that their concerns about contracting an infection themselves and infecting their loved ones could motivate them to adhere to proper HH [29]. One qualitative study found that nurses believed that HH was protective behaviour against infectious diseases [25]. Another study showed that beliefs about consequence were the most compelling facilitator of HH among HCWs [8]. Perceived control, where nurses believed that they possessed or had access to sufficient HH resources to adhere to the recommendations, was strongly associated with adherence intentions, which also led to higher HH compliance [24]. In addition, a previous study explored HCWs' perceptions of design factors in hospitals, and found that participants ranked the factors associated with safety higher than aesthetics [30]. The study also showed that they perceived provision for HH as an important design factor [30], as poorly designed HH stations are perceived to contribute to HAIs [31]. In conclusion, HCWs' concerns, salient beliefs about HH outcomes, and preferred safety features (including HH provision) can explain why HCWs perceive a higher degree of safety if ample HH stations are located appropriately.

In light of these findings, this paper explored the association between interior environments and HH compliance. More than 40% of the participants thought that an insufficient number and inconveniently located HH stations would hinder appropriate HH compliance (see Figure 1). Furthermore, more participants working in OP (>50%), where the HH ratio was the lowest, perceived inconveniently located and an insufficient number of HH stations to be a barrier to HH, compared with the participants working in the ICU and ER, where the HH ratios were

higher. In addition, the participants who thought that inconvenient locations and an insufficient number of HH stations were barriers to HH reported a significantly lower HH compliance rate, compared with the participants who did not perceive a barrier (see Table III).

This study highlights that the perception of barriers affects self-reported HH compliance. These findings echo previous literature about associations between spatial layouts and HH compliance ratios [10]. HCWs have reported several barriers to HH compliance, including environmental barriers, forgetfulness, lack of knowledge and time constraints [32,33]. Among these barriers, resources, including environmental resources (e.g. lack of access), were the most significant barriers to HH, as well as suggestions to facilitate HH [8]. Design factors that easily discourage proper HH compliance include poor accessibility, limited visibility and inconvenient locations [34]. Strategic placement of HH stations has been found to improve HH compliance [35]. Even a small increase in the number of HH stations has been reported to improve HH compliance [14]. Furthermore, noticeable HH stations located adjacent to patients could significantly improve HH compliance in both virtual settings [11] and real environments [36]. As this paper suggests, HCWs perceived more environmental barriers where the HH ratio was lower, and their perception was negatively associated with their self-reported HH compliance rate. According to previous findings, the perception would further negatively impact actual HH compliance. However, only 33% of HH stations were directly visible in patients' rooms, while an increasing distance between patients and HH stations was negatively associated with HH compliance [37]. In addition, the accessibility of HH stations does not always improve HH compliance [16]. For these reasons, multi-factorial strategies, including interior environmental perspectives, should be implemented to enhance HH compliance [38].

Impacts of individual differences

The findings indicated an association between perceived contamination and coping behaviours. Acknowledging this association, the findings further suggested the moderating effect of individual differences (i.e. perceived vulnerability) on the association. These results are in accordance with previous research regarding contamination-related anxiety and avoidance [27], as well as the role of individual differences [26,39]. Avoidance was strongly associated with perceived contamination as well as health anxiety, particularly estimated likelihood of having an illness [27]. Although this study did not specify the role of individual differences, other studies have explored this. Contamination cognitions were strongly associated with behavioural avoidance tasks, including exposing or protecting one's own self, and disgust sensitivity, as an individual difference, mediates the associations [39]. Different studies showed a similar result that individual differences (i.e. disgust propensity) were significantly correlated with avoidance of possible contaminants [26]. However, those studies focused on disgust sensitivity and propensity, whereas this study focused on perceived vulnerability and infectious diseases.

Although the relationships between perceived contamination and behaviours have received attention in the literature [40], a very limited number of studies have investigated perceive contamination and its association with behavioural avoidance [27]. Therefore, the findings of this study could be used to highlight the association between perceived contamination and coping behaviours, including both avoidance and disinfection, and the moderating role of individual differences in perceived vulnerability among HCWs.

Limitations

Due to a number of limitations, the findings of this study should be interpreted with care. First, various confounding variables were not considered. Different factors may affect perceived safety against infectious diseases and behaviours. For the perception of safety, the different work duties, tasks and patients' health conditions in the different departments may affect the participants' perception of safety against infectious diseases. As such, the three different departments may have led to the results, rather than the different environmental features. Furthermore, when the data were collected, no global pandemic existed. If the data had been collected during or immediately after a global pandemic, the HCWs' perceived safety against infectious diseases may have been very different because people tend to perform HH more frequently in the case of global infectious diseases [41]. Similarly, for coping behaviours, self-efficacy, disgust sensitivity and obsessive-compulsive disorder may also affect HCWs' avoidance and/or disinfection behaviours.

Second, as this study was an observational study, the causal relationships between HH compliance and coping behaviours cannot be determined. Rather, this study was only able to show how the environmental features (e.g. HH stations) and perceived contamination were associated with HH compliance and coping behaviours. Therefore, future studies designed with more rigor are needed to further analyse the possible impacts of environmental features on HH compliance, and the impacts of perceived contamination on coping behaviours.

Third, HH compliance and coping behaviours are self-reported values. It remains questionable whether or not actual HH compliance rates are increased when HH stations are present in sufficient numbers and convenient locations. Also, the participants could have reported higher HH compliance and coping behaviours due to social desirability. For these reasons, it remains unproven whether the reported HH ratios and their coping behaviours reflect reality. Hence, future studies should enhance the reliability of data on HH compliance and coping behaviours.

Finally, although the questionnaires asked whether inconveniently located HH stations and an insufficient number of HH stations were potential barriers to HH compliance, observations only collected data about the number of HH stations, not the locations. Based on the body of knowledge, HH compliance was strongly associated with the location of HH stations [14,37]. However, as this study did not observe the locations of HH stations, the results may not depict the true association between the location and number of HH stations with HH compliance rates.

Conflict of interest statement
None declared.

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