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INTRODUCTION

Healthcare-associated infections (HAIs) cause substantial financial and human losses^{1,2}. Preventing HAIs through hand hygiene reduces morbidity, mortality and healthcare costs³⁻⁵. While good hand hygiene is the cornerstone for prevention of HAIs, overall compliance across a range of studies globally is generally poor, and only approximates 40% across healthcare settings⁶.

Hand hygiene with alcohol-based hand rub (ABHR) significantly reduces the transmission of infection in health care settings⁷, and is more effective, time-saving and skin-friendly than traditional handwashing^{8,9}. However, hand hygiene practices can be an obstacle for specific religions such as Sikhism, Hinduism and Islamism due to their prohibition of alcohol use^{1,10,11}. This has become potentially more problematic as recommendations for use of alcohol-based solutions have expanded over the last decade^{1,10}. While participants of a 2002 conference held in Saudi Arabia determined that the Qur'an permitted the use of medicinal agents containing alcohol in any percentage to alleviate illness or contribute to better health if it cannot be substituted by some other substance¹², some HCWs of the Muslim faith are still not willing to use alcohol-based solutions¹⁰, due to concerns about the possible consequences of skin absorption or inhalation of alcohol^{11,13,14}. For example, a 2017 Iranian study demonstrated that 75.4% of nurses were not concerned about respiratory inhalation of alcohol during ABHR use and 77.3% reported that possible alcohol absorption through the skin would not be a problem,

however a minority were concerned about either inhalation or absorption presenting a possible religious conflict ¹⁵.

Culture also has an influence on hand hygiene habits regardless of religion ¹⁶. Hand hygiene is frequently performed based on ancient traditions in certain countries; for example, handwashing always must be performed before lifting anything to one's lips in certain African countries (e.g., Ghana and some other West African countries) ^{1,14}. In other cultures, it is customary to provide a means for hand immersion (a bowl of water with special leaves) outside the door of the house to welcome visitors and allow them to wash their face and hands ^{1,14}. Hand use and specific gestures are significant in certain cultures ^{1,14,17}. African, Hindu, Jewish, and Muslim cultures consider the left hand unclean and used solely for 'hygienic' purposes, while the right hand is reserved for offering, receiving, eating, and gesticulating ^{1,14,17}. Sikh culture deems folding the hands together as greeting, in prayer, or as a gesture of respect. Given the importance of the role of hand hygiene rituals in certain cultures, there is a potential advantage to considering these in the teaching of hand hygiene, particularly for different cultures ^{18,19}. In this way cultural and religious beliefs may influence inherent attitudes to hand hygiene during healthcare.

Behavioural theory is crucial to the development of effective hand hygiene interventions ²⁰⁻²². The Theory of Planned Behaviour (TPB) has been used to understand hand hygiene behaviour in healthcare settings ^{23,24}. The TPB constructs can be directly applied to predicting the effects of HCWs' hand hygiene attitudes, subjective norms, and perceived behavioural control on their hand hygiene intentions, which directly influence HCWs' actual hand hygiene behaviours ²⁴. However, the religious and cultural determinants of hand hygiene behaviour have not been incorporated into this theory and have largely been unexplored in the published literature. While there have been two studies conducted

in the Kingdom of Saudi Arabia (KSA) and Iran examining the influence of religious and cultural beliefs on HCWs' hand hygiene behaviour^{10,13,15}, there is no published research examining religious and cultural beliefs as determinants of HCWs' hand hygiene behaviour in the other countries where similar, but different, religious and cultural customs prevail, such as the United Arab Emirates (UAE). Multimodal hand hygiene programs are well-established in hospitals across the UAE, yet sustaining hand hygiene compliance therein is challenging²². Additional gains in compliance may be obtained by underpinning the elements of hand hygiene programs that take into consideration local religious and cultural beliefs as fundamental determinants of sustained hand hygiene compliance. An exploration of the religious and cultural determinants of hand hygiene behaviour should inform the review and design of hand hygiene programs, especially in Islamic countries such as the UAE where there are prima facie issues related to the use of alcohol.

The aims of this study were two-fold. The first was to explore the TPB variables (i.e., behavioural beliefs, attitudes, normative beliefs, subjective norms, control beliefs, perceived behavioural control and intention), and religious and cultural beliefs of HCWs and Islamic scholars that influence their hand hygiene behaviours. The second was to determine whether religious and cultural beliefs and TPB variables predict hand hygiene behaviours amongst HCWs. From these aims, three research questions were proposed:

1. What TPB variables—behavioural beliefs, attitudes, normative beliefs, subjective norms, control beliefs, perceived behavioural control and intention—influence the hand hygiene behaviour of healthcare workers in the UAE?
2. What religious and cultural beliefs influence the hand hygiene behaviour of healthcare workers in the UAE?

3. Are TPB variables and religious and cultural beliefs predictors of the self-reported alcohol-based hand rubbing of healthcare workers in the UAE?

METHODS

Setting

The study was conducted at a tertiary healthcare facility in Abu Dhabi, UAE.

Study design

A mixed-methods design was employed. Phase 1 explored how participants' (i) behavioural, normative, control, and (ii) religious and cultural beliefs influenced hand hygiene through interviews with key informants and stakeholders. In phase 2, a cross-sectional survey was conducted utilising an existing instrument based on the TPB model by O'Boyle ²⁵, which was adapted to include items on religious and cultural beliefs derived from phase 1, and administered online to determine if it was predictive of hand hygiene behaviour.

Phase 1- exploration of TPB, religious and cultural beliefs

Data collection

Ten people were recruited to phase 1 of the study: four Islamic scholars, who were not HCWs, and six HCWs (two doctors, two nurses and two allied health professionals) who identified as Muslims (n=3), Christians (n=2), or Hindu (n=1). The participants were interviewed individually in person to obtain rich data on hand hygiene and the religious and cultural beliefs that they perceived would influence hand hygiene. The interviews were used to explore individual perceptions of the use of ABHR from religious and cultural perspectives, and in light of these insights what religious- and culturally-based interventions could enhance and motivate hand hygiene practices among HCWs. The interviews lasted

~45 minutes. The interviews were conducted using a set of semi-structured questions for HCWs (Table 1) based on behavioural, normative and control beliefs in the TPB model ²⁶ to prompt discussion about HCWs' hand hygiene beliefs, and a six question guide (Table 2) was used to understand the perception of Islamic scholars in relation to alcohol-based hand rubbing.. A consent form was signed after the participants agreed to take part in the interviews.

Data analysis

Interviews were transcribed and the data underwent thematic analysis following the methods suggested by Clarke, Braun ²⁷. First, familiarisation with the data was achieved through listening to recordings from the 10 participants to become intimately familiar with the data and note any initial analytic observations. The consistency and accuracy of descriptions, supported by verbatim text citation increased study dependability. The verity of transcripts was reviewed upon completion of the recordings, to ensure the accuracy of recording the participants' words, as proposed by Sutton, Austin ²⁸ and Loubere ²⁹. Second, coding of these data related to religious beliefs, cultural beliefs and TPB variables was undertaken. Each item of data was coded and categorized into these three elements. Interpretation was reached by consensus to enhance the trustworthiness and credibility of the analysis. Categories and emergent codes were discussed to ensure preciseness and look for messages that are consistent with, confirm, or expand on current knowledge and theory for this study, by comparing these with the transcripts, correcting misapprehensions where appropriate, and also marking the voice tone, silences and significant pauses. Domain definitions were discussed and agreed by the researchers to ensure consistency throughout the coding process. Where a response was unclear, the principal researcher contacted the participant to clarify the information, to confirm meaning, providing a chance for errors to

be rectified and avoiding misleading information ³⁰. Third, once coding was done, all the coded data relevant to each theme related to religious beliefs, cultural beliefs and TPB variables was collated. Fourth, a review of the themes was undertaken. The themes associated with the religious and cultural beliefs, and TPB variables were reviewed to confirm that they tell a convincing and compelling story about the codes, and the nature of each individual theme, and the relationship between the themes were defined. Fifth, the themes were defined and named. A detailed analysis of each theme was conducted and written up; the core of each theme was identified and a concise and informative name for each theme was constructed. Finally, the analytic narrative and detailed data extracts were written up to inform a coherent narrative about the themes, and these themes were related to the religious beliefs, cultural beliefs and TPB variables in existing literature.

Rigour and Trustworthiness

Rigour and trustworthiness are critical measures that the researcher is concerned about while designing one-on-one interviews, analysing results and judging the quality of the study ³¹. The quality of one-on-one interviews relies on the observer's insights and abilities, making an assessment of reliability difficult ³². A number of techniques were employed during the interview phase, to increase the rigour and trustworthiness of the findings. Alignment of the themes from HCWs and Islamic scholars was a useful form of triangulation that provided some insights into the validity of data. Prolonged engagement and persistent observation were used via combining the one-on-one interviews, emails and written correspondence over an extended period of time. Member-checking of raw data was performed where themes and data collected by digitally recorded interviews were returned to individuals to confirm meaning, providing opportunities for errors to be rectified and avoiding misleading information. Finally, an audit trail was maintained that included

actions and perceptions of participants during the one-on-one interviews that were analyzed for their expressions of meaning through theme and sub-theme coding. All this information permits other researchers to replicate the study and transfer research protocols and processes into other contexts.

Phase 2- modified survey to investigate hand hygiene behaviour

Data collection

Instrument design

The findings of phase 1 informed phase 2 of the study, a cross-sectional survey using a modified existing instrument based on the TPB model by O'Boyle ²⁵. The survey instrument was developed by O'Boyle ²⁵ to measure HCWs' internal motivations to hand hygiene based on a TPB-based theoretical model. The survey was adapted to include items on religious and cultural beliefs derived from phase 1, to determine whether these, along with standard TBP variables, were predictive of self-reported hand hygiene behaviour. The existing TPB-based survey measured self-reported handwashing compliance ²⁵ rather than hand hygiene, which includes ABHR use. Thus, the instrument the term 'handwashing' was changed to 'alcohol-based hand rubbing'. The behavioural, normative, and control beliefs identified from the interviews informed the modification of the existing TPB survey used by O'Boyle ²⁵. The survey is in 7-point Likert scale format (supplementary material online) ranging from 1 (Strongly disagree) to 7 (Strongly agree). A Likert scale was used because a summated multi-item scale is more reliable than a format of single item when measuring a construct, as indicated by Willits ³³. The Marlowe-Crowne Social Desirability Scale short form C was used to determine respondents' tendency to present themselves in a 'socially desirable' way ³⁴.

In order to determine face validity and reliability, the survey tool of 100 items was piloted as suggested by Bartlett ³⁵ and Christodoulou et al. ³⁶, on 35 staff (18 Muslims, 14

Christians, and 3 Hindus) in the Quality Department at the study site. The survey contained 13 sections: 1) demographics; 2) religious beliefs; 3) cultural beliefs; 4) behavioural beliefs; 5) attitudes; 6) normative beliefs; 7) subjective norms; 8) control beliefs; 9) perceived behavioural control; 10) intentions; 11) self-reported alcohol-based hand rubbing behaviour; 12) a social desirability scale; and 13) an opportunity to provide free text comments.

Participants in the pilot were excluded from the final survey sample, as proposed by Jackson, Furnham ³⁷ and Lobiondo-Wood, Haber ³⁸. Subsequently, the item wording of the survey was modified and 26 items were removed based on the suggestions of the pilot respondents. The reliability coefficients for the pilot scales of religious beliefs, cultural beliefs and TPB constructs were measured. The internal consistency, a measure suggested by Pallant ³⁹, was satisfactory, except for religious beliefs, cultural beliefs and the perceived behavioural control scale (Table 3). Five items from the religious beliefs scale, four items from the cultural beliefs scale, and one item from the perceived behavioural control scale were retained, but modified to improve clarity, as they were considered theoretically important. One question was added to the cultural beliefs scale and the item statements were modified to increase clarity in the final survey, based on the feedback from pilot respondents.

Sample size

All personnel at the study site were invited to participate. This included 873 nurses, 329 medical staff (including 30 medical students) and 135 allied health staff (Hospital Human Resources, 2017, pers. comm.). Assuming a 5% margin of error, a 95% confidence level, and a 50% response distribution, the minimum recommended sample size was 178, 268, and 101 for medical, nursing, and allied health staff, respectively ⁴⁰. The number of

medical, nursing, and allied health respondents were 111, 171, and 67, which increased the margin of error by 7.58%, 6.73% and 8.53% respectively. However, the minimum recommended total sample size was 299 and the final number of respondents was 349 resulting in a slightly lower margin of error (4.51%) ⁴⁰.

Survey administration

The final online survey (supplementary material online) took 15-20 minutes to complete and contained 74 items: the religious beliefs scale contained five items; the cultural beliefs scale contained five items; 51 items were related to TPB variables (i.e., 14 behavioural beliefs items, eight attitude items, seven normative beliefs items, one subjective norm, five control beliefs items, two perceived behavioural control items, five intention items, and nine self-reported alcohol-based hand rubbing items), while 13 items were related to the Marlowe-Crowne Social Desirability Scale. Nine items were reverse scored to minimize the risk of acquiescent responses. For each scale, the items were summed to give a total score for that scale. With the exception of the attitudes scale, higher scale scores indicated more positive beliefs about alcohol-based hand rubbing. A higher scale score for attitudes indicated more negative attitudes towards alcohol-based hand rubbing and more positive attitudes towards hand washing. The survey was administered electronically. A survey link and participant information sheet were emailed to potential respondents. Reminders were sent weekly. The principal researcher attended grand rounds, handover and department meetings to encourage survey participation. Participants were offered the use of a mobile device (e.g., iPad; laptop) to complete the survey. Data collection was finalised a month after survey initiation.

Data analysis

IBM SPSS Statistics Version 24 was used to undertake statistical analyses. Frequency and valid percentage were calculated for categorical variables. For each of the scales, mean item scores and standard deviation were calculated.

Reliability indices

Cronbach's alpha was calculated for the scale with >10 items and a threshold of 0.70 was used to demonstrate internal consistency. For scales with <10 items, the mean inter-item correlation (threshold of 0.20) for the items was reported. One item was removed from the cultural beliefs Scale to improve reliability. Cronbach's alpha and mean inter-item correlations for the scales (Table 4) were considered good, as indicated by Pallant ³⁹. The mean inter-item correlation value of the religious beliefs and cultural beliefs scales were 0.20 and 0.22, respectively; this is largely because they are small scales (five and four items, respectively). These scales were newly established for this study, thus, the results could not be compared with other studies.

Inferential statistics

To examine religious and cultural beliefs and the TPB variables related to hand hygiene behaviour, a direct logistic regression model was used (along with age, gender and religion as control variables), as proposed by Field ⁴¹ and Pallant ³⁹.

A correlation analysis (Pearson r) was conducted with study variables to explore the integration of association between religious and cultural beliefs scales and the TPB constructs, as suggested by Field ⁴¹ and Pallant ³⁹. The relationship between the variables and the Marlowe-Crowne Social Desirability Scale was also explored and the alpha level for statistical significance was set as 0.05.

Results

Research question one: themes related to TPB variables

The first study aim was to determine the TPB variables that influenced the hand hygiene behaviour of healthcare workers in the UAE. Thematic analysis of the qualitative interview data from phase 1 yielded six themes associated with HCWs' hand hygiene behaviour as they related to TPB variables: *behavioural beliefs: advantages* (i.e., right practice; clean feeling; eliminating microorganisms; protecting oneself and others from HAIs); 2) *behavioural beliefs: disadvantages* (i.e., handwashing is not cost-effective; limitations of alcohol-based hand solution on soiled hands; hand rub retains dead microorganisms); 3) *normative beliefs: supportive* (i.e., influence of Ignaz Semmelweis; supervisors' preference; experts' expectations; agreement by peers; patients' demands); 4) *normative beliefs: unsupportive* (i.e., doctors' disagreement); 5) *control beliefs: facilitating factors* (i.e., personal beliefs; professionalism; existing policies and regulations; accessibility of ABHR); and 6) *control beliefs: inhibiting factors* (i.e., inaccessibility and unavailability of hand hygiene facilities; skin-product incompatibilities).

Behavioural beliefs: advantages

The participants' beliefs indicated that they saw hand hygiene as an advantageous behaviour in many ways. They detailed their belief that it was a morally important behaviour in that it is the right thing to do: "*I perform hand hygiene not because people approve or like it. I am doing it because this is the right thing to do*" (Nurse 2). In addition, handwashing was a behaviour that enabled them to achieve cleanliness: "*I prefer using water and soap because this will give a feeling that I am clean*" (Nurse 1). Another participant remarked that: "*I can wash my hands properly in the sense that I can wash and rinse the germs off my hands*" (Doctor 2). The participants also emphasized that hand

hygiene protects one-self and others from HAIs. One stated: *"By practicing alcohol-based hand rubbing, I can keep my family, patients and colleagues safe"* (Nurse 2).

Behavioural beliefs: disadvantages

Participants held behavioural beliefs that detailed some disadvantageous aspects of hand hygiene. They perceived that traditional handwashing was costly and less time-effective than alcohol-based hand rubbing, as stated: *"Handwashing consumes water and hand towels"* (Allied Health 1); *"Handwashing requires more time than alcohol-based hand rubbing"* (Allied Health 2). Despite this, the participants' beliefs demonstrated the known limitations of alcohol-based rubs for soiled hands: *"Alcohol-based hand rubbing will not be effective if hands are soiled"* (Allied Health 2). In addition, participants commented that alcohol-based hand rub retains dead microorganisms on hands: *"Alcohol-based hand rubs deactivate and kill the germs but the 'killed' germs still remain on my hands"* (Nurse 1).

Normative beliefs: supportive

The participants believed that the support of important people could promote hand hygiene compliance. They suggested that the influence of hand hygiene pioneers and supervisors' preference could be factors influencing their hand hygiene behaviour: *"...I always teach all my students about Semmelweis. He probably was the one influencing my hand hygiene behaviour"* (Doctor 1); *"My supervisors are always focusing on alcohol-based hand rubbing than handwashing because it is more practical"* (Doctor 2). Participants commented that experts' expectations and agreement by peers could also contribute to hand hygiene behaviour: *"The infection prevention and control committee has the strongest influence on me and they always expect me to perform hand hygiene"* (Doctor 2); *"I have not heard my colleagues complaining that they don't prefer alcohol-based hand rubbing"* (Nurse 2). The participants also highlighted patients' demands for hand hygiene: *"The patients will*

request us to do hand hygiene when they see us...The patients are more on [sic] the hand rubbing. I have personally seen patients using alcohol-based hand rub although there is [a] handwashing sink nearby" (Allied Health 2).

Normative beliefs: unsupportive

Participants were disturbed by the non-supportive beliefs of superiors that could also influence hand hygiene behaviours: *"We are having troubles educating or reinforcing the hand hygiene practices to old and senior doctors. They just don't believe it" (Doctor 2).*

Control beliefs: facilitating factors

Participants held control beliefs that facilitated hand hygiene behaviours. They recognized personal beliefs as an enabler to hand hygiene behaviours: *"It is the matter of whether people believing [sic] it or not. I do not think it's related to religion or culture" (Allied Health 1).* Participants also commented that hand hygiene is performed due to staff professionalism and they abided by existing hospital rules and regulations: *"I am a trained healthcare worker, so I should motivate myself to perform hand hygiene" (Nurse 1); "...I don't need to be motivated because I am convinced to follow the hospital rules" (Nurse 2).* Since the handwashing facilities were inaccessible, the accessibility of ABHR facilities enhanced hand hygiene behaviour: *"Alcohol-based hand rubs are already accessible in almost all places" (Doctor 1).*

Control beliefs: inhibiting factors

Participants' control beliefs indicated that hand hygiene behaviour could be inhibited in several ways. Inaccessibility and unavailability of hand hygiene facilities or products could prevent them from performing hand hygiene: *"The hand washing sink is not accessible everywhere" (Nurse 2); "Alcohol-based solution in the dispenser is empty, most probably alcohol-based hand rub was being used so frequently and it ran out" (Doctor 1).* Participants

also expressed concerns about skin-product incompatibilities that hinder individuals' use of ABHR: *"...there will be people who are allergic to the alcohol-based products, since alcohol may cause dryness"* (Nurse 2). In addition, one of the barriers was that patient factors could contribute to HAIs: *"I believe in hand hygiene but it cannot prevent all HAIs. Other factors such as co-morbidities also contribute to HAIs"* (Nurse 1).

Research question two: themes related to religious and cultural beliefs

The second study aim was to determine what religious and cultural beliefs were associated with HCWs' hand hygiene behaviour. A further six themes related to religious and cultural beliefs that influence hand hygiene behaviour were identified: 1) *religious requirement for good hygiene*; 2) *personal culture in hygiene behaviour*; 3) *preventing harm to self and others*; 4) *alcohol-based hand rubs are acceptable to Islam*; 5) *doubt and conflict between knowledge and beliefs*, and; 6) *dealing with doubt: increasing knowledge and awareness*.

1. Religious requirement for good hygiene

Participants indicated that hand hygiene was a fundamental tenant of Islam. As one participant suggested: *"Hand hygiene is in fact important. It is actually part of the religion [sic] requirement"* (Islamic Scholar 3). Moreover, they indicated that being clean was fundamental for all religious groups, as this excerpt illustrates: *"I believe all religions require us to be clean and it is clearly mentioned in the holy books of Islam and Christianity"* (Nurse 2). All participants emphasized the importance of cleanliness.

2. Alcohol-based hand rubs are acceptable to Islam

Although hand hygiene was reported to be a core religious requirement, there were no details on how it should be practiced, for example *"There is nothing specific in the Quran"* (Islamic Scholar 3). What was important was that hands were clean, not how they

should be cleaned. Most believed that: *"As long as people don't ingest it, an alcohol-based solution with any percentage is allowed in Islam...alcohol-based hand rub is used to kill germs on hands, it is 'halal' (permissible) to use it"* (Islamic Scholar 1). Thus, according to most participants, ABHR use by Muslims is appropriate, regardless of the associated prohibition of alcohol ingestion.

3. Personal culture in hygiene behaviour

Participants identified that hand washing was a ubiquitous cultural practice, whereas alcohol-based hand rubbing was a work-associated behaviour: *"People including me are used to soap and water since we were small and before we are eating. When we were told to use alcohol-based hand rub at work, it took us some time to get used to this new practice"* (Allied Health 1). This illustrates the strong belief amongst the participants that hand hygiene was cultural: *"As long as it is used as part of cleaning whether alcohol or non-alcohol), it is allowed in all cultures"* (Allied Health 2).

4. Preventing harm to self and others

For participants, hand hygiene and in particular ABHR use at work, was key to preventing harm to self and to others: *"As long as the process...can make us clean and protect us or people from infections, it is acceptable in Islam"* (Islamic Scholar 2). Participants reported a strong directive from the Islamic Authority that protecting individuals from harm is a virtuous deed, and hand hygiene was an act that achieved this: *"According to the General Authority of Islamic Affairs and Endowments in UAE, alcohol-based solution is permitted for external use, since the intention is to protect patients from harm. Thus, we should be motivated anytime to use alcohol-based hand rubs, in order not to spread infections to others"* (Doctor 2). This reinforces the earlier reported theme of the religious requirement for hand hygiene, and underscores the religious requirement that "motivates"

the use of ABHR for patient safety. Despite this, there was some skepticism regarding the use of ABHR that illustrates a conflict between knowledge and beliefs.

5. Doubt and conflicts between knowledge and beliefs

While one participant was aware of the acceptability of ABHR in Islam, he still feared intoxication, *"I totally avoid the use of alcohol-based hand rub although I know this is not against Islam. I am still in doubt whether the alcohol content can make me drunk because I have never used it"* (Islamic Scholar 2). This participant expressed concern about skin absorption if the alcohol concentration was more than 60%, suggesting that alcohol concentration higher than this would lead to intoxication: *"The alcohol content in the alcohol-based hand rub is 60% and has not made people drunk so far after applying on hands, so I would say alcohol-based hand rub with 60% or less content is allowed to be used"* (Islamic Scholar 2). While others did not specifically raise fears of skin absorption, several mentioned that 60% alcohol was acceptable, which might indicate they see this as the maximum acceptable concentration.

6. Dealing with doubt: increasing knowledge and awareness

Education and awareness-raising strategies were suggested by participants to improve ABHR use among HCWs: *"People should be educated about the importance of using alcohol-based hand solution to kill germs, to protect ourselves and patients"* (Islamic Scholar 1); *"If people are aware that we have a lot of infections in the hospital ... because we are not using alcohol-based hand rub, believe me that people will start using it. This is because Allah taught us not harm people"* (Islamic Scholar 2). One proposed strategy was to involve Islamic scholars in lectures about the value of ABHR use and reinforce how this practice does not harm individuals. Participants suggested that HCWs be encouraged to own the process: *"You can let people know that they are the ones who own the process and they are*

the ones who can protect patients from getting the infections" (Islamic Scholar 4).

Participants signaled that these strategies address potential concerns about ABHR that could enhance hand hygiene.

Research question three: predictors of hand hygiene behaviour

The third aim of the study was to determine via a survey whether the identified TB variables and religious and cultural beliefs were predictors of the self-reported alcohol-based hand rubbing of healthcare workers in the UAE. Of 1337 eligible participants, 349 participants (26.1%) responded: 171 were nurses (49%), 111 were medical staff (31.8%) and 67 were allied health staff (19.2%). Direct logistic regression assessed the impact of various factors and covariates on the likelihood that respondents would perform alcohol-based hand rubbing. The dependent variable was 'Uses alcohol-based hand rub': No (0) and Yes (1). Respondents in the 'No' category identified using soap and water, but no alcohol. The full model containing 12 predictors - age (in years), gender (male/female), religion (Muslim/non-Muslim), religious beliefs, cultural beliefs, behavioural beliefs, attitudes, normative beliefs, subjective norms, control beliefs, perceived behavioural controls and intention - was statistically significant ($\chi^2 (12, n = 241) = 77.92, p = < 0.001$, Nagelkerke $R^2 .329$), indicating that some or all of the predictors had explanatory power. Only attitudes and cultural beliefs were statistically significant predictors (Table 5).

The strongest predictor of self-reported alcohol-based hand rubbing was cultural beliefs ($p = 0.01$; odds ratio (OR) 95% CI 1.15 [1.03-1.17]); a one-point increase in cultural beliefs was associated with a 15% increase in the odds of alcohol-based hand rubbing, controlling for all other factors. The item strongly related to cultural beliefs was 'consistently using alcohol-based hand rub to decontaminate my hands is permissible in my culture' (corrected item-total correlation values of 0.39). The OR 95% CI 0.87 (0.82-0.92) for

attitudes was <1; higher attitudes scores were associated with a 13% decrease in the odds of hand rubbing, when controlling for other factors. Out of the attitudes items, the item most strongly related to the attitude score was 'consistently using alcohol-based hand rub to decontaminate my hands is frustrating' with a corrected item-total correlation value of 0.85.

The inter-correlations for all study variables were presented in table 6. The variables were significantly correlated either positively or negatively, with small to large strength correlations ranging from 0.27 to 0.75 ($p < 0.001$). There was no significant correlation between scores on the Marlowe-Crowne scale and those variables.

Discussion

Existing research demonstrates that the TPB model predicts hand hygiene behaviour⁴². The participants clearly identified the advantages of performing hand hygiene for themselves, and their patients and colleagues, which is consistent with existing research²³. Participants also perceived disadvantages to performing hand hygiene; however, the concerns about wasting consumables (i.e., water, hand towels) and the time required to perform handwashing were identified as the main disadvantages, which was consistent with previous research²³. A range of people (e.g., colleagues, supervisors, experts) were identified as sources of support for the participants for performing hand hygiene, aligned with the findings of Whitby and McLaws⁴³. Patients were also identified as key supportive people, complementing the findings of a study emphasizing their potentially convincing role in enhancing hand hygiene compliance among HCWs⁴⁴. For the important people not supportive of hand hygiene, the strongest theme to emerge was reports of non-compliance and active discouragement of hand hygiene from some senior doctors, reported also in

previous studies ^{45,46}, but not others ^{47,48} where senior physicians supported hand hygiene initiatives. Addressing doctors' beliefs is particularly important given the leadership roles they play in healthcare settings ²². Participants were able to clearly describe the key factors that facilitated hand hygiene, and particularly noted that having readily accessible hand hygiene infrastructure is crucial in patient care areas. Similar findings had been outlined for hospital infection prevention and control initiatives in general ⁴⁷. Although not raised in previous TPB studies examining hand hygiene beliefs, personal beliefs regardless of religious and cultural norms were cited as motivators to perform hand hygiene in the present study. Furthermore, professionalism emerged as another key facilitator to hand hygiene compliance, which has been previously reported ⁴⁸. Finally, hand hygiene policy was a motivator for the participants to engage in more vigilant hand hygiene ⁴. Congruent with the identified facilitators, the main barrier to performing hand hygiene was the non-accessibility of handwashing sinks and alcohol-based hand rub facilities, which was a common finding in previous studies ^{49,50}. Interestingly, in the present study, the issue of co-morbidity was cited as a barrier due to concerns about its contribution to HAIs, suggesting that a motivation to comply with hand hygiene behaviour was in conflict with patient factors. As in previous studies, the issue of irritant contact dermatitis from the use of alcohol-based rubs was raised as a drawback to performing hand hygiene ^{51,52}, despite the fact that ABHR is less likely to cause skin irritation than handwashing.

In addition to exploring HCWs' hand hygiene behaviour as it related to the variables of TBP, research question two explored religious and cultural beliefs associated with hand hygiene behaviour. As identified earlier, religious and cultural beliefs were found to influence HCWs' hand hygiene behaviour in HCWs in Saudi Arabia and Iran, but there has been no published research beyond this to other similar, but different, jurisdictions. This

study explored several religious and cultural beliefs that possibly influenced alcohol-based hand rubbing among HCWs in the UAE. Most interview participants believed that hand hygiene was important to maintain cleanliness and this is consistent with guidance from both the World Health Organization ¹ and Mathur ⁵³ who indicated that personal hygiene is a key component of human well-being regardless of religion. Handwashing was perceived as an important part of ritual purity in Islam where it is required before prayer. While ingestible alcohol is prohibited in Islam, most raised no objection to ABHR use, seeing it as aligned with the teachings of the Qur'an, which permits any substance to be used to contribute to better health ¹². In addition, the majority felt ABHR use should be actively encouraged to prevent transmission of HAIs. However, one Islamic scholar was concerned about alcohol absorption via the skin, although studies have shown that blood alcohol levels are insignificant (ethanol) or undetectable (iso-propyl) after ABHR use ¹². The perceptions reported by this participant are inconsistent with the Muslim Scholars' Board, which allows use of medicines that contain alcohol in any percentage ¹². The perception of this Islamic scholar may cause conflicts between knowledge and beliefs amongst his followers, and thus undermine the use of ABHR for hand hygiene. Similarly, culture is influential when it comes to hand hygiene behaviour and this was consistent with theme 3. Participants approved of ABHR use, although the majority preferred handwashing, which they were brought up with. This was congruent with inherent handwashing practice, where the development of handwashing patterns occurs during the first 10 years of life ⁴³. This subsequently influenced attitudes towards elective handwashing; participants believed handwashing removed microorganisms from the skin after healthcare delivery more effectively, which conflicts with the scientific evidence indicating ABHR is the gold standard for hand hygiene ^{54,55}, unless hands are visibly soiled.

Research question three examined the extent to which this predictive ability extended to variables of TPB and the associated religious and cultural factors. Religious beliefs were not a significant predictor, while cultural beliefs and attitudes were significant predictors of alcohol-based hand rubbing. An increased cultural beliefs score was associated with an increase in the odds of alcohol-based hand rubbing. This indicated that HCWs' compliance with alcohol-based hand rubbing largely relies on cultural beliefs. Since 'consistently using alcohol-based hand rub to decontaminate my hands is permissible in my culture' was identified as the strongest item within the scale, the value of alcohol-based hand rubbing should be embedded in the culture of healthcare ¹. Likewise, the high efficacy and accessibility of alcohol-based hand rub, when compared with handwashing should be considered when planning a strategy to promote ABHR use in healthcare to encourage positive attitudes towards its use, to address the concern that consistent use of alcohol-based hand rub is frustrating. Additionally, cultural beliefs were significantly associated with attitudes and other TPB variables. Thus, cultural beliefs should be integrated in the TPB model to enhance the predictive capacity of the TPB model. Although religious beliefs were not a significant predictor, several strategies were suggested to deal with doubts about ABHR raised during the phase 1 study. The first strategy is to consistently share hospital HAI incidence, to enhance behavioural beliefs on the benefits of ABHR use (e.g., ABHR is more effective than handwashing) and the negative consequences people might experience if hand hygiene is not performed. The second targets control beliefs by helping religious scholars and HCWs to understand the scientific evidence underlying the recommendation to use ABHR, particularly that alcohol levels found in the blood are insignificant or undetectable after using ABHR ^{1,56}. This allows HCWs to raise religious concerns regarding

the ABHR use in the presence of religious scholars, potentially enhancing normative beliefs when they perceive support from religious scholars for ABHR.

This study had several limitations. Firstly, the convenience sampling method may create a selection bias ³⁹ towards HCWs with an interest in hand hygiene. Secondly, the low allied health response rate restricted the study's findings principally to nurses and medical staff. Thirdly, socially desirable responding during the interviews is a potential limitation as one interviewee was a senior HCW, although in the survey no social desirability response bias was detected, as described by Pallant ³⁹.

Conclusions

This is the first study to examine TPB variables, and religious and cultural beliefs related to ABHR in the UAE. The results suggest that cultural beliefs and attitudes predicted ABHR use and were associated with other variables in the TPB model. Addressing cultural beliefs and attitudes can potentially enhance and sustain ABHR use. It is important to address determinants related to these two predictors when developing strategies to promote ABHR use. Local studies exploring ABHR use using a TPB model with integrated cultural beliefs will provide a more accurate picture in specific contexts.

Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Authorship statement

WK collected the data. All authors conceived of the study, contributed to the study design, development of the interview and survey instrument, data analysis, manuscript writing, and approved the final version of the manuscript.

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Ethical Considerations

Ethics approval was obtained from Griffith University (2016/318) and Mafrag Hospital Human Research Ethics Committees (MAF-REC_12/2015_03).

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Table 1: Interview Semi-Structured Question Guide for Healthcare Workers

Theory of Planned Behaviour (TPB) component	Elicited beliefs	Question
Behavioural beliefs	Advantages	What are the advantages of performing handwashing? What are the advantages of alcohol-based hand rubbing?
	Disadvantages	What are the disadvantages of performing handwashing? What are the disadvantages of alcohol-based hand rubbing?
Normative beliefs	Normative approval	Who are the people (or groups of people) important to you who would approve of you performing handwashing? Who are the people (or groups of people) important to you who would approve of you performing alcohol-based hand rubbing?
	Normative disapproval	Who are the people (or groups of people) important to you who would disapprove of you performing handwashing? Who are the people (or groups of people) important to you who would disapprove of you performing alcohol-based hand rubbing?
Control beliefs	Barriers	What prevents or make it difficult for you to perform handwashing? What prevents or make it difficult for you to perform alcohol-based hand rubbing?
	Facilitators	What helps or motivates you to perform handwashing? What helps or motivates you to perform alcohol-based hand rubbing?

Table 2: Interview Semi-Structured Question Guide (Islamic Scholar)

Questions	
1	Could you describe the role of hand hygiene in Islam?
2	What type of hand hygiene solution/process is typically required?
3	How does Islam look upon the use of alcohol-based solutions for hand hygiene? Why?
4	What are your own personal views on the use of alcohol-based hand hygiene solutions in healthcare?
5	In what situations should Muslims be encouraged to use alcohol-based hand rubs?
6	Can you advise on any strategies to improve hand hygiene compliance by Muslim health care workers that might address potential concerns about using alcohol-based solutions for hand hygiene?

Table 3: Reliability indices of the *pilot* version of religious beliefs, cultural beliefs and TPB scales

Scale	Cronbach's alpha ($n=33$)	Mean inter-item correlation ($n=33$)
Religious Beliefs (5 items)	-	0.10
Cultural Beliefs (4 items)	-	0.13
Behavioural beliefs (14 items)	0.81	-
Attitude (8 items)	-	0.40
Normative Beliefs (7 items)	-	0.88
Subjective Norms (1 item)	Not applicable	Not applicable
Control Beliefs (5 items)	-	0.40
Perceived Behavioural Control (2 items)	-	0.14
Intention (5 items)	-	0.22

Table 4: Reliability indices of the religious beliefs, cultural beliefs and TPB scales

Scale	Cronbach's alpha ($n=349$)	Mean inter-item correlation ($n=349$)
Religious Beliefs (5 items)	-	0.20
Cultural Beliefs (5 items)	-	0.22
Behavioural beliefs (14 items)	0.83	-
Attitude (8 items)	-	0.60
Normative Beliefs (7 items)	-	0.87
Subjective Norms (1 item)	Not applicable	Not applicable
Control Beliefs (5 items)	-	0.65
Perceived Behavioural Control (2 items)	-	0.50
Intention (5 items)	-	0.44

Table 5: Factors that predict likelihood of alcohol-based hand rubbing

	B	S.E.	Wald	df	<i>p</i>	Odds Ratio	95.0% C.I. for Odds Ratio	
Age	-0.03	0.16	2.32	1	0.13	0.98	0.94	1.01
Gender	-0.13	0.37	0.13	1	0.42	0.88	0.43	1.80
Religion	1.00	0.33	0.09	1	0.76	1.11	0.58	2.10
Religious beliefs	-0.03	0.44	0.31	1	0.58	0.98	0.89	1.06
Cultural beliefs	0.14	0.05	6.51	1	0.01	1.15	1.03	1.27
Behavioural beliefs	-0.03	0.02	1.78	1	0.18	0.97	0.93	1.01
Attitudes	-0.14	0.03	23.17	1	<0.001	0.87	0.82	0.92
Normative beliefs	0.06	0.04	2.36	1	0.13	1.06	0.98	1.15
Subjective Norms	0.04	0.09	0.24	1	0.63	1.05	0.87	1.25
Control beliefs	0.02	0.05	0.26	1	0.61	1.03	0.93	1.13
Perceived behavioural control	-0.02	0.07	0.07	1	0.79	0.98	0.85	1.13
Intention	0.02	0.03	0.43	1	0.51	1.02	0.96	1.08
Constant	2.44	2.17	1.27	1	0.26	11.52		