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Understanding the determinants of Australian hospital nurses' hand hygiene decisions following the implementation of a national hand hygiene initiative

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Abstract

Hand hygiene is the primary measure in hospitals to reduce the spread of infections, with nurses experiencing the greatest frequency of patient contact. The '5 critical moments' of hand hygiene initiative has been implemented in hospitals across Australia, accompanied by awareness-raising, staff training and auditing. The aim of this study was to understand the determinants of nurses' hand hygiene decisions, using an extension of a common health decision-making model, the theory of planned behaviour (TPB), to inform future health education strategies to increase compliance. Nurses from 50 Australian hospitals ($n = 2378$) completed standard TPB measures (attitude, subjective norm, perceived behavioural control [PBC], intention) and the extended variables of group norm, risk perceptions (susceptibility, severity) and knowledge (subjective, objective) at Time 1, while a sub-sample ($n = 797$) reported their hand hygiene behaviour 2 weeks later. Regression analyses identified subjective norm, PBC, group norm, subjective knowledge and risk susceptibility as the significant predictors of nurses' hand hygiene intentions, with intention and PBC predicting their compliance behaviour. Rather than targeting attitudes which are already very favourable among nurses, health education strategies should focus on normative influences and perceptions of control and risk in efforts to encourage hand hygiene adherence.

Introduction

Improving hand hygiene among healthcare workers is the primary measure to reduce the risk of healthcare associated infections in hospitals. High compliance rates of hand hygiene practice assist in the significant cost of healthcare-associated infections on patient health and the economic burden on health systems [1]. In 2009, WHO adopted new global guidelines outlining five critical moments for hand hygiene that Hand Hygiene Australia has reworded specifically as: before touching a patient (Moment 1), before a procedure (Moment 2), after a procedure (Moment 3), after touching a patient (Moment 4) and after touching a patient's surroundings (Moment 5) [2]. Australian data reporting compliance rates of healthcare workers with the five moments in hospitals indicate a relatively high level of compliance, with less compliance at

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Moment 5 (after touching a patient's surroundings), suggesting opportunities for improvement in the consistent performance of hand hygiene practice [3].

Improving hand hygiene practice is desirable but achieving sustained change to clinical practice can be difficult. The acute healthcare environment is busy and complex, and competing priorities may impair good hand hygiene practice. Hence, theory and research which can help to target inventions for improved hand hygiene practices are of great importance. Alongside other hospital-based employees, nurses play a central role in efforts to reduce healthcare-associated infections, especially given their majority representation among healthcare workers in hospitals. Further, nurses experience the most physical contact with patients with an associated greatest potential to spread infection [4]. Identifying the determinants of hand hygiene decisions among hospital-based nurses, therefore, is vital to inform intervention strategies to encourage greater compliance.

In addition to the myriad of environmental (e.g. accessibility of hand hygiene products, [5]) and structural (e.g. workload [6–8]) factors that influence nurses' hand hygiene decisions, these actions are determined by the individual's beliefs and perceptions related to hand hygiene and its performance. There are a number of theoretical approaches that examine the socio-cognitive mechanisms underpinning decision making for health behaviour that can be applied to understand compliance with hand hygiene guidelines by nurses in a hospital context. These approaches include the health belief model (e.g. [9]) and social cognitive theory (e.g. [10]). Although these models give consideration to the role of benefits and barriers to performing a given behaviour, they tend to ignore the important role of social influences on behavioural performance. The theory of planned behaviour (TPB; [11]), the most common decision-making model that guides the majority of the research in the health field (see [12]), acknowledges both the role of social influences, along with personal attitudes and perceptions of control over behaviour. Given that hospital workers are ensconced within a group context whereby the influences of others are likely to affect their decision making, the TPB was considered to be a useful theoretical approach for the current research.

The TPB posits that intention to perform a behaviour is the best predictor of behaviour, with intention being determined by three constructs: attitude (i.e. positive or negative evaluations of the behaviour), subjective norm (i.e. perceptions of pressure from others to perform or not perform the behaviour) and perceived behavioural control (PBC) (i.e. the amount of control one perceives they have over behavioural performance; also believed to influence behaviour directly; [11]). The TPB also proposes that the antecedents of attitude, subjective norm and PBC are corresponding salient beliefs reflecting the underlying cognitive structure that determines an individual's intention and behaviour [11]. According to Ajzen ([13] p. 2), to engender change so that positive intentions translate into consistent behaviour, identifying which of the determinants of intention (e.g. attitude, subjective norm etc) are influential is necessary so that these factors and the associated beliefs underlying these constructs can be targeted to facilitate change.

Despite recent debate about the utility of the TPB in health psychology applications (e.g. [14]), there is meta-analytic support for the TPB across a wide variety of behaviours [15] and specifically for health behaviours [16]. Across 185 TPB studies, the standard predictors accounted for 39% of variance in intention and 27% of variance in behaviour [15]. For hand hygiene decisions, there is support for the model in predicting people's hand hygiene practices in hospitals and other contexts [6–8, 17–19]. For instance, in a study of 104 hospital-based healthcare workers, attitude (and personal responsibility) predicted hand hygiene intentions, with intention and PBC predicting hand hygiene behaviour [17]. Further, in a study of 120 hospital nurses, subjective norm predicted intention, with intention predicting self-reported hand hygiene [18]. Despite evidence supporting the general utility of the TPB including for hand hygiene, Ajzen [11, 20] posits that the model is open to the inclusion of additional predictors if they increase the explained variance over

and above the standard TPB constructs and make theoretical sense.

Given the weaker evidence for the subjective norm-intention link [21, 22], alternative conceptualizations of norms have been proposed including a group norm from a social identity theory [23] and self-categorization theory [24] approach. From this perspective, group norms are conceptualized as reflecting both the attitudes and behaviours of members of a key referent group that the individual identifies with [25, 26]. Given the team-based work culture for hospital nurses, it is expected that the perceived attitudes and behaviour of co-workers (i.e. other nurses) for hand hygiene will impact on individual nurses' hand hygiene decisions.

Risk estimates do not usually feature explicitly in TPB studies although are prominent in other, especially health-based, decision-making models such as the health belief model (e.g. [9]). Further, there is some evidence that people's perceptions of risk can influence their hand hygiene intentions [27]. Based on the potentially strong association between infection risk and hygiene decisions, both risk susceptibility (perceived risk of developing a health problem) and risk severity (perceived severity of a health problem and its potential consequences), constructs borrowed from the health belief model, were examined in this study to assess their role in nurses' hand hygiene decision making.

Finally, although lacking stronger evidence for a direct role of knowledge in determining intentions in the TPB (e.g. [28]), there is other evidence reporting a link between people's hand hygiene knowledge and their compliance (see [29] for a review) suggesting that knowledge may influence decision making especially after the implementation of a new initiative where awareness-raising and staff training occur to educate employees about a new regime. Both subjective and objective levels of knowledge were considered potentially important influences on nurses' hand hygiene adherence in this study.

The aim this study was to test the utility of an extended TPB in predicting hospital nurses' intentions and behaviour to comply with hand hygiene recommendations following the implementation of a national hand hygiene initiative. It was expected that, according to the TPB, attitude, subjective norm and PBC would predict intention, and that intention and PBC would predict hand hygiene behaviour. For the additional variables, it was expected that perceptions of the hand hygiene attitudes and behaviour of other nurses (group norm), risk perceptions (susceptibility and severity) and hand hygiene knowledge (subjective and objective) would predict nurses' intentions to comply with hand hygiene recommendations.

Methods

Design and procedure

The study received ethical clearance from 22 Human Research Ethics committees (including a university human research ethics committee) and received the appropriate site-specific governance approvals from each hospital. The study was prospective in design, with a hard copy survey completed at Time 1 and a follow-up measure of behaviour completed by email or phone 2 weeks later. Nurses currently working in Intensive Care Units, general medicine, or general surgical wards (identified by consulted Infection Control personnel as medium or high healthcare associated infection risk wards) from 50 public hospitals across all state/territories in Australia were chosen randomly and given the survey to complete and return either to their manager in a sealed envelope or via reply-paid mail. Each survey had a pen and small chocolate attached to it as a thank you gift and all participants who completed the surveys at both time-points had the option of providing their details to be eligible for a chance to win one AUD$1000 store voucher per state/territory.

The five moments hand hygiene initiative was implemented between 3 and 18 months prior to the completion of the surveys (with roll-out dates varying from state to state). The initiative consisted primarily of in-service training sessions, reminder messages/posters placed prominently around the hospital, and active monitoring of hand hygiene compliance via audits carried out by Infection

Control Personnel. All nurses in the study would have been exposed to the reminder messages and monitoring and most nurses should have attended an in-service training session, although some nurses will have missed the training due to leave and shift clashes.

Participants

At Time 1, 59.5% ($n = 2378$) of those nurses approached to participate in the study completed the questionnaire. Participants at Time 1 were mostly female (84%; 11.2% males, 4.8% did not specify), aged between 18 and 67 years ($M = 38$; SD = 11 years), and had an average 14 years of nursing experience (range from 0 to 47 years). Of those who completed the Time 1 measures, a smaller number elected to and could be contacted 2 weeks later (56% by email, 44% by phone) for the Time 2 measure of prospective behaviour, resulting in 797 participants (34% of the original sample). Tests were conducted to determine any significant differences in responses on the study's main measures (i.e. intention, attitude, subjective norm, PBC, subjective knowledge, objective knowledge, risk susceptibility, risk severity) between participants who completed the follow-up questionnaire and those who did not. The only significant difference (at $P < 0.001$) was that those participants who completed both surveys scored higher on objective knowledge ($M = 4.69$, SD = 1.19) than those who only completed the Time 1 survey ($M = 4.36$, SD = 1.25).

Measures

Following TPB recommendations [30], the target behaviour of hand hygiene was: 'performing hand hygiene at all 5 moments during the next 2 weeks'. Based on nationally endorsed guidelines [2], definitions of hand hygiene were provided to nurses at the beginning of the questionnaire (see Table II). The TPB scales were constructed according to recommended guidelines [11]. To create the scales, responses to the items were averaged.

Intention

Three items assessed intention to comply with the five moments of hand hygiene in the subsequent 2 weeks on seven-point Likert scales: 'To what extent do you plan to perform hand hygiene at all 5 moments' (1 = 'to a small extent'; 7 = 'to a large extent'); 'It is likely that I will perform hand hygiene at all 5 moments' (1 = 'extremely unlikely'; 7 = 'extremely likely'); and 'I plan to perform hand hygiene at all 5 moments' (1 = 'strongly disagree'; 7 = 'strongly agree').

Attitude

Attitude was measured with six items responding to the statement 'I think performing hand hygiene at all 5 moments during the next two weeks is. . .'A seven-point semantic differential response format was used, anchored by: 'good/bad', 'useful/useless', 'wise/foolish', 'safe/unsafe', 'valuable/worthless' and 'beneficial/harmful'. Scores were reversed so that a higher score corresponded to a more positive attitude.

Subjective norm

Subjective norm was measured with three items framed in relation to the next 2 weeks and used a seven-point Likert scale (1 = 'strongly disagree'; 7 = 'strongly agree'). The items were: 'Most people who are important to me would think that my performing hand hygiene at all 5 moments would be desirable'; 'Most people who are important to me would approve of me performing hand hygiene at all 5 moments'; 'Most people who are important to me would think that I should perform hand hygiene at all 5 moments'.

PBC

PBC was measured with four items addressing perceived control over the subsequent 2 weeks, using a seven-point Likert scale (1 = 'strongly disagree'; 7 = 'strongly agree'). The items were: 'I have complete control over whether I perform hand hygiene at all 5 moments'; 'It is mostly up to me whether or not I perform hand hygiene at all 5

moments'; 'I am confident that I could perform hand hygiene at all 5 moments'; 'It would be easy for me to perform hand hygiene at all 5 moments'.

Group norm

Group norm was measured with two items addressing perceptions of others over the subsequent 2-week period, using a seven-point Likert scale (1 = 'none'; 7 = 'all'): 'Thinking about the nurses/midwives on your ward: How many of them do you think would perform hand hygiene at all 5 moments?' and 'Thinking about the nurses/midwives on your ward: How many of them would think that performing hand hygiene at all 5 moments is a good thing to do?'

Risk–susceptibility

Perceived risk susceptibility related to hand hygiene practices over the subsequent 2 weeks as measured with the item 'If I didn't perform hand hygiene at all 5 moments, it is likely to lead to the spread of infection'. The Likert response scale ranged from 1 ('strongly disagree') to 7 ('strongly agree').

Risk–severity

Perceived risk severity related to hand hygiene practices over the subsequent 2 weeks were measured with the item 'If there is a spread of infection at work, it is a very serious problem'. The Likert response scale ranged from 1 ('strongly disagree') to 7 ('strongly agree').

Subjective knowledge

Subjective knowledge was measured with the item 'Overall, how would you rate your knowledge of hand hygiene practices?' using a Likert scale from 1 ('very poor') to 7 ('excellent').

Objective knowledge

Objective knowledge was assessed with six multiple choice questions adapted from material available on-line from Hand Hygiene Australia [31] with two questions about the type and frequency of hygiene agent and four questions depicting hypothetical hospital situations asking when hand hygiene should be performed at specific moments. An example scenario, asking when hand hygiene should be performed, is: 'A phlebotomist applies a tourniquet to the patient and palpates the vein, prepares the blood tubes, dons gloves and inserts the needle into the vein, draws blood, disposes of the needle and removes gloves.' (with four options of responses when hand hygiene could be performed and instructions to select all that apply). Participants scored 1 if they answered the question correctly and 0 if they were incorrect. The total score was the number of correct answers (range = 0–6).

Prospective behaviour

For participants who agreed to be recontacted, prospective behaviour was assessed 2 weeks later via an email survey or telephone follow-up call asking the item 'Thinking about the past 2 weeks, to what extent did you perform hand hygiene at all 5 moments?' The Likert scale ranged from 1 ('a small extent') to 7 ('a large extent'). To provide more detail about compliance across each of the 5 different moments and in an attempt to provide greater reliability for the one-item measure used in the analyses by considering behaviour performance across the different scenarios, additional questions asked participants 'During the past 2 weeks, to what extent did you perform hand hygiene at the following moments?' whereby participants rated each moment (e.g. 'before touching a patient') separately on Likert scales from 1 ('a small extent') to 7 ('a large extent'). The one-item measure was correlated strongly with the average of the five questions ($M = 6.23$; SD = 0.67) assessing compliance at each moment ($r = 0.99$, $P < 0.001$)

Statistical analysis

After inspecting the correlation matrix to identify any overly high inter-correlations, two hierarchical regression analyses assessed the effects of the extended TPB factors in predicting (i) intentions and (ii) behaviour. Significant predictors were identified at the final step of each analysis by

Table I. *Means (M), standard deviations (SD), and inter-correlations (Pearson's r) for the study's variables* (n = *2127*)

Variable	*M*	SD	2	3	4	5	6	7	8	9	10
1. Intention	6.49	0.70	0.25***	0.38***	0.54***	0.46***	0.46***	0.31***	0.37***	0.08***	0.38***
2. Attitude	6.69	0.90	—	0.22***	0.23***	0.20***	0.22***	0.14***	0.16***	0.09***	0.12***
3. Subjective norm	6.36	0.91		—	0.32***	0.30***	0.33***	0.22***	0.21***	0.07***	0.12***
4. PBC	6.19	0.85			—	0.39***	0.38***	0.24***	0.31***	0.05**	0.33***
5. Group norm	5.76	0.89				—	0.37***	0.21***	0.30***	0.05*	0.29***
6. Risk-susceptibility	6.49	0.84					—	0.48***	0.22***	0.05*	0.20***
7. Risk-severity	6.76	0.57						—	0.20***	0.06**	0.13***
8. Subjective knowledge	6.10	0.77							—	0.09***	0.28***
9. Objective knowledge[a]	4.48	1.24								—	0.03
10. Behaviour	5.80	1.00									—

Note. For prospective behaviour, $n = 746$. PBC, perceived behavioural control.
[a]Scale from 0 to 6.
$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

noting confidence interval values and inspection of *P* values with a general rule of *P* values < 0.001 reflecting significant predictors, with the stronger predictors among those included in the analyses noted also. Further, the results of mixed model analyses testing for any clustering effects as a function of the hospital where each nurse was employed showed little influence, based on small within-hospital correlation coefficients, for the analyses predicting intention ($r = 0.012$) and behaviour ($r = 0.005$). In a similar vein, the results of mixed model analyses testing for any clustering effects as a function of the state (location) which determined the roll-out date of the intervention showed no to little influence, based on negligible within-state correlation coefficients, for the analyses predicting intention ($r = 0.003$) and behaviour ($r = 0.000$).

Results

Descriptive statistics and inter-correlations for all variables are presented in Table I. Mean scores on all variables were high (>6 on a seven-point scale) except for group norm and behaviour which were slightly lower, with the average response for objective knowledge (measured on a six-point scale) also reflecting a moderately high score. All correlations with intention were significant, with PBC, risk susceptibility and group norm as the strongest correlates. All correlations with subsequent behaviour at 2-week follow-up were significant except for objective knowledge, with intention and PBC as the strongest correlates. Table II presents the mean levels of compliance across each of the five critical hand hygiene moments self-reported at Time 2.

Table II. *Means (M), standard deviations (SD) and sample sizes* (n) *for the five hand hygiene moments at Time 2*

Moment	*M*	SD	*n*
Moment 1: Before touching a patient	6.02	1.09	797
Moment 2: Before a procedure	6.63	0.71	787
Moment 3: After a procedure or body fluid exposure risk	6.78	0.56	790
Moment 4: After touching a patient	6.35	0.87	791
Moment 5: After touching a patient's surroundings	5.54	1.19	791

Note. A higher score indicates greater compliance. The definition of hand hygiene provided to nurses was: 'Hand hygiene is a general term applying to the use of soap/solution (non-antimicrobial or antimicrobial) and water, or a waterless antimicrobial agent to the surface of the hands. This is irrespective of glove use, as the use of gloves does not replace the need for hand hygiene by either hand rubbing or hand washing. The five moments for hand hygiene have been identified as the critical times when hand hygiene should be performed. We are interested in what you think about performing hand hygiene at the following five moments: Moment 1: Before touching a patient; Moment 2: Before a procedure; Moment 3: After a procedure or body fluid exposure risk; Moment 4: After touching a patient; Moment 5: After touching a patient's surroundings.'

Table III. *Hierarchical regression analysis testing the predictors of nurses' hand hygiene compliance intentions* (n = *2127)*

	Variable	B	95% Cl for B	β	R^2	ΔR^2
Step 1					0.35***	
	Attitude	0.08	[0.05, 0.11]	0.11***		
	Subjective norm	0.16	[0.13, 0.19]	0.21***		
	PBC	0.37	[0.34, 0.40]	0.45***		
Step 2					0.45***	0.10***
	Attitude	0.04	[0.02, 0.07]	0.05		
	Subjective norm	0.09	[0.06, 0.12]	0.12***		
	PBC	0.25	[0.22, 0.28]	0.30***		
	Group norm	0.14	[0.12, 0.17]	0.18***		
	Risk-susceptibility	0.15	[0.11, 0.18]	0.18***		
	Risk-severity	0.06	[0.02, 0.11]	0.05		
	Subjective knowledge	0.12	[0.09, 0.16]	0.14***		
	Objective knowledge	0.01	[−0.01, 0.03]	0.02		

Note: A higher score indicates a greater intention. B, unstandardized regression coefficient; Cl, confidence interval; β, standardized regression coefficient; PBC, perceived behavioural control.
***$P < 0.001$.

A hierarchical multiple regression analysis was used to predict hand hygiene intentions (see Table III). The standard TPB constructs of attitude, subjective norm, and PBC were entered at Step 1. The additional factors of group norm, subjective knowledge, objective knowledge, perceived risk susceptibility, and perceived risk severity were entered in Step 2. The TPB variables in Step 1 explained 35% of the variance, $F(3, 2123) = 380.52$, $P < 0.001$. At Step 1, the significant predictors were attitude, subjective norm, and PBC (with PBC and subjective norm as the strongest predictors). The additional factors introduced in Step 2 accounted for a further 10.3% of the variance, $F_{\text{change}}(5, 2118) = 79.61$, $P < 0.001$. The final model accounted for 45.3% of the variance in intentions, $F(8, 2118) = 218.87$, $P < 0.001$. The significant predictors at the final step were subjective norm, PBC, group norm, subjective knowledge, and risk susceptibility (with PBC, group norm, and risk susceptibility as the strongest predictors).

A second hierarchical multiple regression was performed predicting hand hygiene behaviours at the 2-week follow-up (see Table IV). The standard TPB constructs of intentions and PBC, the factors for which direct paths to behaviour are specified, were entered at Step 1. The additional factors introduced in Step 2 were attitude, subjective norm, group norm, subjective knowledge, objective knowledge, perceived risk susceptibility, and perceived risk severity. As shown in Table IV, the TPB variables in Step 1 accounted for 17.6% of the variance in behaviour, $F(2, 743) = 79.09$, $P < 0.001$. At Step 1, the significant predictors were intention and PBC (with intention as the stronger predictor). The additional factors introduced in Step 2 accounted for a further 3.6% of the variance, $F_{\text{change}}(7, 736) = 4.79$, $P < 0.001$. The final model accounted for 21.1% of the variance in hand hygiene behaviours, $F(9, 736) = 21.93$, $P < 0.001$. At the final step of the analysis, the significant predictors of behaviour were intention and PBC (with intention as the stronger predictor).

The regression analyses predicting intention and behaviour were performed also controlling for demographic factors (sex, age, years of nursing experience) which produced a similar set of results as reported earlier and none of the background demographic variables were significant at the final step of the analyses (see Tables V and VI).

Discussion

The results of this study offer support for an extended TPB in understanding the hand hygiene decisions among hospital-based nurses following the implementation of an initiative articulating the crucial

Table IV. *Hierarchical regression analysis testing the predictors of nurses' hand hygiene behaviour* (n = *746*)

	Variable	B	95% CI for B	β	R^2	ΔR^2
Step 1					0.18***	
	Intention	0.44	[0.33, 0.55]	0.29***		
	PBC	0.24	[0.14, 0.33]	0.19***		
Step 2					0.21***	0.04***
	Intention	0.36	[0.24, 0.48]	0.24***		
	PBC	0.19	[0.09, 0.29]	0.15***		
	Attitude	0.03	[–0.06, 0.11]	0.02		
	Subjective norm	–0.09	[–0.17, –0.01]	–0.08		
	Group norm	0.14	[0.05, 0.22]	0.12		
	Risk-susceptibility	0.08	[–0.02, 0.18]	0.06		
	Risk-severity	–0.08	[–0.22, 0.07]	–0.04		
	Subjective knowledge	0.17	[0.07, 0.27]	0.12		
	Objective knowledge	–0.01	[–0.06, 0.05]	–0.01		

Note: A higher score indicates more compliant behaviour. B, unstandardized regression coefficient; CI, confidence interval; β, standardized regression coefficient; PBC, perceived behavioural control.
***$P < 0.001$.

moments of adherence. Subjective norm, control perceptions, group norm, risk susceptibility, and subjective knowledge all emerged as significant predictors of nurses hand hygiene compliance intentions, with intention and control perceptions influencing their hand hygiene behaviour decisions. Self-reported behavioural adherence at follow-up was moderately high, suggesting somewhat encouraging levels of compliance. Nevertheless, the findings suggest opportunities for greater compliance especially for the moment that has been previously identified as the most difficult to achieve high adherence (i.e. after touching a patient's surroundings; see [3]).

For the standard TPB constructs, support was found for pressure from important others and control perceptions influencing nurses' intentions to adhere to hand hygiene guidelines rather than personal attitudes. Consistent with O'Boyle *et al.* [18], pressure from important others (subjective norm) influenced nurses' hand hygiene intentions. Further, in this study, control perceptions had an impact on nurses' intentions to perform hand hygiene at all five moments. Interestingly, although the impact of attitude was weaker than expected, the mean was very high suggesting that hand hygiene attitudes are already very favourable among nurses. The overall variance accounted for in intentions by the standard TPB constructs is comparable with meta-analytic results [15]. In accordance with the TPB, intention and PBC predicted hand hygiene behaviour in a similar vein to Jenner *et al.* [17]. Nurses with stronger intentions and perceptions of control over performing the behaviour were more likely to report higher levels of hand hygiene performance at the 2-week follow-up, with intention as the stronger predictor. The amount of variance these predictors accounted for in behaviour, however, is slightly lower than Armitage and Conner's meta-analytic results, perhaps because hand hygiene is more habitual compared with other health behaviours [32].

For the additional constructs, group norm, risk susceptibility and subjective knowledge were significant predictors of hand hygiene intentions (with group norm and risk susceptibility as the strongest predictors of the additional constructs). Accordingly, nurses' perceptions of their co-workers' approval and adherence to the five critical moments of hand hygiene, the belief that failing to adhere to these moments may lead to the spread of infection, and the belief of being knowledgeable about hand hygiene fostered compliance intentions. The former finding highlights, consistent with predictions, that the perceived norm of relevant referent groups (i.e. pro-compliance norms of nursing colleagues) is an important driver of individuals' decision making and offers support for an extended TPB

Table V. *Hierarchical regression analysis testing the predictors of nurses' hand hygiene compliance intentions controlling for demographic variables of sex, age and years of nursing experience* (n = *2122*)

	Variable	B	95% Cl for B	β	R^2	ΔR^2
Step 1					0.01***	
	Sex[a]	−0.18	[−0.28, −0.86]	−0.08***		
	Age	0.01	[0.00, 0.10]	0.09		
	Years of experience	0.00	[−0.01, 0.00]	−0.01		
Step 2					0.36***	0.35***
	Sex	−0.14	[−0.21, −0.06]	−0.06		
	Age	0.00	[0.00, 0.01]	0.07		
	Years of experience	0.00	[−0.01, 0.00]	−0.01		
	Attitude	0.08	[0.06, 0.11]	0.11***		
	Subjective norm	0.16	[0.14, 0.20]	0.22***		
	PBC	0.37	[0.33, 0.40]	0.44***		
Step 3					0.45***	0.10***
	Sex	−0.09	[−0.17, −0.02]	−0.04		
	Age	0.00	[0.00, 0.01]	0.03		
	Years of experience	0.00	[0.00, 0.00]	0.00		
	Attitude	0.04	[0.02, 0.07]	0.05		
	Subjective norm	0.10	[0.07, 0.13]	0.13***		
	PBC	0.24	[0.21, 0.28]	0.30***		
	Group norm	0.14	[0.11, 0.17]	0.18***		
	Risk-susceptibility	0.17	[0.13, 0.20]	0.18***		
	Risk-severity	0.04	[0.00, 0.09]	0.04		
	Subjective knowledge	0.11	[0.08, 0.15]	0.12***		
	Objective knowledge	0.01	[−0.01, 0.03]	0.01		

Note: A higher score indicates a greater intention. B, unstandardized regression coefficient; Cl, confidence interval; β, standardized regression coefficient; PBC, perceived behavioural control.
[a]Sex coding: females = 0, males = 1.
***$P < 0.001$.

which draws on a social identity and self-categorization approaches (e.g. [25, 26]) in the health-behaviour domain. Given the potentially strong association between infection risk and hygiene decisions, the perceived risk of developing a health problem (i.e. infection) was predicted and found to be influential in nurses' intentions to comply with the critical moments; however, perceived risk severity was not influential. Given that the high mean and small variability of risk severity showed that nurses viewed the spread of infection as a very serious health issue, a ceiling effect may potentially have occurred and could have accounted for the findings for risk severity. Finally, it was subjective knowledge, but not objective knowledge, that was a significant predictor in determining whether nurses intended to adopt hand hygiene guidelines. It is possible that nurses' perceptions of being knowledgeable about hand hygiene practices, irrespective of their actual knowledge, may be associated with a bolstered self-confidence, leading to stronger intentions to be hand hygiene-compliant. The weak relationship between subjective and objective knowledge is notable and indicates that nurses may not recognize their factual knowledge. Perhaps due to this misperception, nurses' objective knowledge had little bearing on hand hygiene decisions. Given that objective knowledge may be linked to the 'effectiveness' of hand hygiene in preventing the spread of infection, efforts to align nurses' factual with perceived knowledge could be worthwhile.

Table VI. *Hierarchical regression analysis testing the predictors of nurses' hand hygiene behaviour controlling for demographic variables of sex, age and years of nursing experience* (n = *713*)

	Variable	B	95% CI for B	β	R^2	ΔR^2
Step 1					0.12	
	Sex	−0.21	[−0.44, 0.02]	−0.07		
	Age	0.01	[0.00, 0.02]	0.14		
	Years of experience	−0.01	[−0.02, 0.00]	−0.13		
Step 2					0.18***	0.17***
	Sex	−0.07	[-0.28, 0.14]	−0.02		
	Age	0.01	[0.00, 0.02]	0.08		
	Years of experience	−0.01	[−0.02, 0.00]	−0.10		
	Intention	0.43	[0.31, 0.54]	0.28***		
	PBC	0.24	[0.15, 0.34]	0.20***		
Step 3					0.22***	0.04***
	Sex	−0.05	[−0.26, 0.16]	−0.02		
	Age	0.01	[−0.01, 0.01]	0.05		
	Years of experience	−0.01	[−0.02, 0.00]	−0.09		
	Intention	0.35	[0.23, 0.48]	0.23***		
	PBC	0.20	[0.10, 0.29]	−0.16***		
	Attitude	0.03	[–0.06, 0.12]	−0.03		
	Subjective norm	–0.10	[–0.19, –0.01]	–0.09		
	Group norm	0.14	[0.05, 0.23]	0.12		
	Risk-susceptibility	0.08	[–0.03, 0.19]	0.06		
	Risk-severity	–0.06	[–0.20, 0.09]	–0.03		
	Subjective knowledge	0.17	[0.07, 0.27]	0.12		
	Objective knowledge	0.00	[–0.06, 0.06]	0.00		

Note: A higher score indicates more compliant behaviour. B, unstandardized regression coefficient; CI, confidence interval; β, standardized regression coefficient; PBC, perceived behavioural control.
[a]Sex coding: females = 0, males = 1.
***$P < 0.001$.

The findings of this study can inform health education strategies to improve hand hygiene compliance among hospital nurses. First, the impact of both subjective norm and PBC on intention suggests that strategies should focus on others' approval in general of nurses performing hand hygiene and foster a sense of control over performing the behaviour (e.g. you are ultimately responsible to ensure compliance and you can do it) including by overcoming known barriers to compliance such as lack of time and forgetfulness. For the additional constructs, the role of group norm as a predictor suggests that encouraging the notion that other nurses are performing hand hygiene would be beneficial as making hand hygiene adherence normative is likely to lead to expectations of compliance. For subjective knowledge, it may be useful to remind nurses that they know and understand the five moments to increase compliance and, in relation to perceived susceptibility, stress that poor hand hygiene 'does' lead to the spread of infection. Thus, messages could incorporate nurses' susceptibility perceptions with wording such as 'It could be the next "moment" you miss that is responsible for an infection outbreak'.

Despite the strengths of the study including a theory-based examination of an important health behaviour using a large and representative sample of Australian nurses working in moderate-to-high infection risk wards, there are a number of limitations. There may have been a self-selection bias with more hand hygiene compliant nurses agreeing to participate. There was a low retention rate at follow-up which may, in part, have been due to the request for identifiable information (first name) if phone rather email contact was elected (to enable the

correct identification of a participant if providing a shared phone number). Analyses revealed a significant difference between completers of both surveys and those who completed the Time 1 predictor variables only on objective knowledge, suggesting that those nurses with greater knowledge about hand hygiene were more motivated to provide follow-up behaviour data. This study relied on self-report measures; ideally, the measure of hand hygiene behaviour would be complemented by objective observation and/or peer and supervisor ratings or, if self-report measures are used, to use multi-item measures, e.g. of component behaviours. Of note, in this study, the correlation between the one-item behaviour measure and the average of the five component behaviours was very high at 0.99. In addition, the objective measure of knowledge was created for the purposes of this study and stronger validity and reliability testing of this instrument would be preferable. Although nurses play a central role within hospital environments in terms of patient contact and care, future research should examine the utility of the identified model with other hospital-based workers and in other healthcare settings (e.g. private hospitals, aged care facilities). Given the role of norms (subjective and group) in this study, future research could examine the influence of the norms of other key peer groups (doctors, allied health professionals) in greater detail. Further, given the focus of this study on individual beliefs and perceptions, future research should examine the interplay between these perceptions and more structural and environmental factors determining hand hygiene compliance.

Overall, this study highlights the key influences of hospital workers' hand hygiene compliance decision making and can assist by informing health education strategies to improve adherence to recommendations. Continued efforts to understand and increase hand hygiene compliance among hospital workers, including monitoring success after the implementation of identified initiatives to promote recommended practice, are vital to assist in reducing the impact of the spread of infection in hospitals especially to benefit the health of those patients in high risk hospital wards.

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Conflict of interest statement

None declared.

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