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Examining the behavioral pathways between clinical governance and hand hygiene compliance in nosocomial infection prevention

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Abstract

This study aims to analyze the factors influencing hand hygiene behavior among healthcare workers by integrating the Theory of Planned Behavior (TPB) and the COM-B model among staff at Dr. Hardjono Hospital. This study employed a quantitative approach with a survey design. Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS). The minimum sample size was determined using G*Power, resulting in a minimum requirement of 103 respondents. This study involved 300 healthcare workers. Data were collected using a structured questionnaire and analyzed to test the measurement model, structural model, and predictive ability of the model. The results showed that attitude and perceived behavioral control had a positive effect on hand hygiene intention, while subjective norms had no significant effect. Furthermore, ability and opportunity had a positive effect on hand hygiene motivation. Hand hygiene behavior was directly influenced by intention, while perceived behavioral control and motivation did not show a significant direct effect. The results of the Importance–Performance Map Analysis (IPMA) identified intention and perceived behavioral control as the constructs with the highest level of importance, but with relatively suboptimal performance. This study concludes that improving hand hygiene behavior among healthcare workers needs to focus on strengthening intention and perceived behavioral control, supported by a work environment that minimizes situational barriers. These findings provide important implications for the development of more effective and sustainable nosocomial infection prevention interventions.

Keywords: Hand hygiene behavior, Theory of planned behavior, COM-B model, SEM-PLS, Healthcare workers

Introduction

Nosocomial infections, or Healthcare-Associated Infections (HAIs), are one of the greatest challenges facing healthcare systems worldwide. The WHO reports that millions of patients experience HAIs each year, leading to increased morbidity and mortality, as well as a significant global economic burden as Ojanperä, Kanste, & Syrjala (2020) stated. The impact of HAIs not only reduces patients' quality of life but also prolongs length of stay, increases antibiotic use, and puts additional pressure on hospital capacity. Yet, the majority of HAIs can be prevented through strict infection control standards, particularly hand hygiene practices in accordance with WHO guidelines as stated on Ambrosch et al., (2020) and Du et al., (2021).

In Indonesia, the HAIs problem remains at an alarming level. Many hospitals, including regional hospitals, have not achieved adequate hand hygiene compliance. Several reports indicate that healthcare workers' adherence to the WHO's five moments of hand hygiene remains low, even in high-risk units such as the ICU and NICU. Dr. Hardjono Hospital in Central Java is an example of a hospital that is strengthening its clinical governance system, but still faces challenges such as inconsistent hand hygiene compliance across units. This situation reflects a broader problem in Indonesian hospitals, particularly in large cities like Jakarta, which face limited resources, weak clinical leadership, an unsupportive organizational culture, and minimal staff participation in service quality audits as stated on Sithole et al., (2024).

Economically, improving hand hygiene compliance is one of the most efficient interventions to reduce HAIs. Based on Tchouaket et al., (2022) and Tchouaket et al., (2021) Interventions such as behavioral training, providing handwashing facilities, and increasing the availability of hand rub have been shown to reduce hospital operational costs and increase healthcare worker productivity. However, the success of these interventions is heavily influenced by behavioral factors, the work environment, and how consistently

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the hospital implements clinical governance.

Unfortunately, research examining how clinical governance can influence hand hygiene compliance is still very limited. Most previous studies have focused solely on individual factors within healthcare workers, such as attitudes and social norms on Sin & Rochelle, (2022), or environmental factors such as work opportunities and motivation on Gaube et al., (2021) and Zheng et al., (2022). No research has comprehensively explained how clinical governance can shape hand hygiene behavior through psychosocial and structural mechanisms, especially in the context of a developing country with limited resources like Indonesia. This is a significant research gap and also provides room for novelty that has not been widely discussed in the literature.

Based on these conditions, this study aims to understand in-depth how clinical governance can influence healthcare workers' hand hygiene compliance behavior. This study seeks to describe the relationship between clinical governance systems and factors shaping healthcare workers' behavior, including their ability, opportunity, motivation, and inclination to adhere to hand hygiene standards. Through this approach, this study not only seeks to identify factors that act as barriers and drivers of behavior but also to explain how these mechanisms operate within the operational context of hospitals in Indonesia. Thus, this study is expected to provide a strong foundation for developing strategies to improve hand hygiene compliance that are more effective, relevant, and sustainable in an effort to reduce the number of nosocomial infections in Indonesian hospitals.

Literature Review

Attitude and intention

Attitude, in the context of hand hygiene, refers to healthcare workers' positive or negative assessments of the importance of performing the practice to prevent infection transmission. Positive attitudes are typically formed from the belief that hand hygiene is effective in reducing the risk of infection, as demonstrated by research during the COVID-19 pandemic based on Du et al., (2021) and other nosocomial infection control efforts based on Ojanperä, Kanste, & Syrjala, (2020). When healthcare workers perceive hand hygiene as beneficial, relevant, and valuable for patient safety, they are more likely to develop an internal commitment to implement it.

Sin & Rochelle, (2022) and Haenen et al., (2022) said that intention is the readiness or commitment of healthcare workers to consistently perform hand hygiene behaviors. Studies show that intention is a key predictor of handwashing behavior in healthcare facilities. Intention does not develop spontaneously but is influenced by beliefs in the effectiveness of the practice and positive perceptions of the expected outcomes.

Previous research consistently shows that attitude plays a strong role in shaping healthcare workers' intentions to practice hand hygiene. Sin and Rochelle (2022) found that the more positive healthcare workers' attitudes toward handwashing practices, the higher their intention to practice them. Positive attitudes reflect the belief that the behavior is important, thus fostering commitment to action. Similarly, Haenen et al. (2022) reported that positive perceptions of the benefits of hand hygiene correlated with stronger intentions in clinical practice. Findings by Ojanperä et al. (2020) also showed that healthcare workers with positive attitudes toward infection prevention demonstrated higher levels of intention to comply with hand hygiene protocols.

Based on this literature, positive attitudes can be interpreted as an important trigger that fosters healthcare workers' cognitive motivation to commit to hand hygiene. In the Indonesian clinical context, which still faces compliance challenges, understanding how attitudes influence intentions is crucial for designing effective adherence-enhancing strategies.

Therefore, the proposed hypothesis is:

H1: Attitude has a positive effect on Intention.

Subjective norm and Intention

Subjective norm is a crucial factor influencing a person's intention to perform a behavior, including compliance with handwashing in healthcare facilities.

According to Ajzen, within the Theory of Planned Behavior (TPB) framework, subjective norm is defined as an individual's perception of social pressure from significant others in their lives to perform or not perform a behavior. Sin and Rochelle (2022) explain that, in the context of healthcare workers, subjective norm reflects the influence of coworkers, superiors, and organizational culture on the intention to comply with hand hygiene protocols. Meanwhile, Ojanperä, Kanste, & Syrjala (2020) emphasize that social norms in hospitals can also shape collective commitment to maintaining hygiene standards, thus encouraging healthcare workers to adapt their behavior to group expectations. Ambrosch et al. (2020) add that in crisis situations such as a pandemic, social pressure and peer supervision can be significant drivers in increasing compliance with handwashing practices. Thus, subjective norm is not merely an individual perception but also encompasses the social dynamics and organizational culture that influence intention to act.

Several previous studies have shown a positive relationship between subjective norms and healthcare workers' intention to practice hand hygiene. Sin and Rochelle (2022) found that perceptions of peer and supervisor expectations significantly increased nurses' intention to adhere to hand hygiene standards during the COVID-19 pandemic. Haenen et al. (2022) also reported that in long-term care facilities, healthcare workers who perceived social support and peer pressure tended to be more consistent in their intention to practice hygiene behaviors. Another study by Du et al. (2021) confirmed that subjective norms were an important predictor of hand hygiene intentions and behavior, particularly in units with a high risk of nosocomial infections. Based on these findings, it can be concluded that perceptions of social norms supporting hand hygiene play a significant role in shaping healthcare workers' intentions and are therefore a factor that needs to be considered in efforts to improve compliance.

Therefore, the hypothesis proposed in this study is as follows:

H2: Subjective norms have a positive influence on healthcare workers' intention to practice hand hygiene.

Perceived behavioral control and Intention

Perceived Behavioral Control (PBC) is a key concept in the Theory of Planned Behavior (TPB) that describes an individual's perception of their ability to perform a particular behavior, including adherence to handwashing in healthcare facilities. According to Ajzen, PBC reflects the extent to which an individual feels they have control over internal and external factors that influence the implementation of a behavior, such as skills, time, and available resources. Sin and Rochelle (2022) emphasized that for healthcare workers, PBC encompasses perceptions of their ability to comply with hand hygiene protocols, including the availability of handwashing facilities, soap, hand sanitizer, and adequate time within their work routines. Ojanperä, Kanste, & Syrjala (2020) added that this perception of control is also influenced by adequate organizational support, training, and supervision. Meanwhile, Ambrosch et al. (2020) emphasized that during a pandemic, PBC becomes even more critical because healthcare workers must balance high work pressure with the need to maintain hygiene, so perceived control over behavior significantly determines intention and consistency of action. Thus, PBC not only measures individual capabilities, but also the extent to which the environment and resources support desired behavior.

Previous research has shown a positive relationship between PBC and intention to practice handwashing. Sin and Rochelle (2022) found that nurses who perceived sufficient control over handwashing time and facilities had a higher intention to implement hygiene protocols. Haenen et al. (2022) reported that healthcare workers in long-term care facilities who perceived a supportive work environment, such as the availability of hand sanitizer and easily accessible sinks, were more cognitively committed to practicing hygiene. Du et al. (2021) added that perceived control also influenced healthcare workers' preparedness in high-risk situations for nosocomial infections, thereby increasing their intention to consistently practice handwashing. These findings suggest that PBC acts as a reinforcement of intention, especially when individuals perceive they are able to overcome physical and organizational barriers to implementing hygiene behaviors.

Based on the above description, the hypothesis proposed in this study is as follows:

H3: Perceived behavioral control has a positive influence on healthcare workers' intention to practice handwashing.

Hand hygiene opportunity and hand hygiene motivation

Hand hygiene opportunity refers to environmental or situational factors that enable healthcare workers to effectively practice handwashing. Zheng et al. (2022) explain that opportunity includes the availability of handwashing facilities, access to hand sanitizer, supportive hospital policies, and an organizational culture that encourages compliance. Gaube, Fischer, & Lermer (2021) add that opportunity also includes work arrangements that facilitate healthcare workers' hygienic practices, such as strategic sink placement and sufficient time within routines. Meanwhile, Ambrosch et al. (2020) emphasize that a conducive environment, including colleague compliance and adequate supervision, increases intrinsic motivation to practice handwashing, especially in high-risk situations such as the COVID-19 pandemic. Thus, hand hygiene opportunity is not only about physical facilities, but also organizational support that creates optimal conditions for hygienic behavior.

Several studies support a positive relationship between opportunity and handwashing motivation. Zheng et al. (2022) showed that healthcare workers with easy access to handwashing facilities and a supportive work environment were more motivated to maintain hand hygiene. Haenen et al. (2022) reported that long-term care facilities with hand sanitizer availability and active supervision policies demonstrated increased healthcare workers' motivation to adhere to protocols. Sithole et al. (2024) added that staff understanding of the existence of clinical protocols supported by the work environment strengthened their motivation to consistently practice hygiene. These findings confirm that opportunity plays a significant external factor facilitating the development of handwashing motivation.

Based on this review, the following hypothesis is proposed:

H4: Hand hygiene opportunity has a positive influence on healthcare workers' hand hygiene motivation.

Hand hygiene capability and hand hygiene motivation

Hand hygiene capability refers to the ability of healthcare workers to understand, apply, and maintain proper handwashing techniques. Zheng et al. (2022) stated that capability encompasses the knowledge, practical skills, and individual competencies to carry out hygienic practices according to standards. Gaube, Fischer, & Lermer (2021) added that this capability can be strengthened through regular training, clinical audits, and ongoing feedback. Sin & Rochelle (2022) emphasized that healthcare workers who have a deep understanding of the risks of nosocomial infections and proper handwashing techniques tend to have higher intrinsic motivation to consistently implement these practices. Thus, capability acts as an internal foundation that drives individual motivation to comply with protocols.

Several studies support the relationship between capability and motivation. Zheng et al. (2022) found that healthcare workers with adequate skills and knowledge are more motivated to routinely practice hygienic practices. Gaube, Fischer, & Lermer (2021) showed that practical training and regular audits improve individual skills, which directly boosts motivation to adhere to handwashing standards. Ambrosch et al. (2020) added that increased professional competence and awareness amid the COVID-19 pandemic significantly boosted healthcare workers' motivation to protect patients and themselves through hygienic practices. This finding confirms that capability is a crucial factor shaping healthcare workers' internal motivation.

Based on this review, the following hypotheses are proposed:

H5: Hand hygiene capability has a positive influence on healthcare workers' hand hygiene motivation.

Intention and hand hygiene behavior

Intention is an individual's cognitive readiness to perform a specific behavior and is a key predictor of actual behavior in the Theory of Planned Behavior stated on Ajzen (1991). Sin & Rochelle (2022) stated that intention reflects healthcare workers' awareness and commitment to consistently adhere to handwashing practices. Haenen et al. (2022) emphasized that strong intentions are reflected in the implementation of concrete actions in the field, such as handwashing frequency according to protocol. Meanwhile, Du et al. (2021) showed that clear intentions regarding hygiene compliance are directly related to the reduction of nosocomial infections, as healthcare workers with strong intentions tend to be more consistent and accurate in implementing handwashing.

Empirical research supports a positive relationship between intention and handwashing behavior. Sin & Rochelle (2022) found that healthcare workers with strong intentions were more consistent in implementing handwashing, while Haenen et al. (2022) reported that strong intentions were a key indicator of successful hygiene protocol implementation in long-term care facilities. The findings of Du et al. (2021) confirm that without clear intentions, handwashing compliance often declines even when facilities are available. Thus, intention serves as a cognitive link between psychological factors and actual actions in the field.

Based on the above description, the following hypothesis is proposed:

H6: Intention has a positive influence on healthcare workers' handwashing behavior.

Perceived behavioral control and hand hygiene behavior

In addition to influencing intention, perceived behavioral control also has a direct impact on handwashing behavior. PBC describes the extent to which individuals feel able to control their behavior, including access to facilities and technical capabilities stated on Sin & Rochelle, (2022). Haenen et al. emphasized that healthcare workers who perceive a high level of control over their environment and resources are more likely to consistently practice handwashing. Ambrosch et al. (2020) added that organizational support, facility availability, and colleague compliance enhance perceived control, which ultimately strengthens actual action in the field.

Research shows a positive relationship between PBC and behavior. Sin & Rochelle (2022) found that healthcare workers with a high level of perceived control were more consistent in handwashing. Haenen et al. (2022) reported that physical or time constraints can decrease compliance, but a strong perception of control can mitigate these barriers. The findings of Ambrosch et al. (2020) also showed that healthcare workers who perceived organizational support and adequate resources were more able to consistently implement hygiene behaviors, despite high work pressure.

Based on this, the following hypotheses were proposed:

H7: Perceived behavioral control has a positive influence on healthcare workers' handwashing behavior.

Hand hygiene motivation and hand hygiene behavior

Motivation is the internal and external forces that drive individuals to perform certain behaviors. In the context of handwashing, motivation includes professional awareness, moral responsibility for patient safety, and intrinsic and extrinsic drives to comply with protocols. Zheng et al. (2022) emphasized that motivation is the primary driver in the COM-B model for converting intentions into concrete actions. Ambrosch et al. (2020) added that healthcare workers motivated by the values of professionalism and patient safety are more consistent in implementing handwashing, especially in high-risk situations. Gaube, Fischer, & Lermer (2021) emphasized that motivation interacts with capability and opportunity to determine actual behavior in the field.

Several studies support a positive relationship between motivation and behavior. Zheng et al. (2022) found that healthcare workers who are intrinsically motivated and supported by adequate opportunities and capabilities demonstrate higher compliance. Ambrosch et al. (2020) emphasized that professional motivation drives consistent action even when workloads are high. Gaube, Fischer, & Lermer (2021) added that the combination of motivation, skills, and organizational support significantly improves handwashing behavior.

Based on this description, the following hypothesis is proposed:

H8: Hand hygiene motivation has a positive influence on healthcare workers' handwashing behavior.

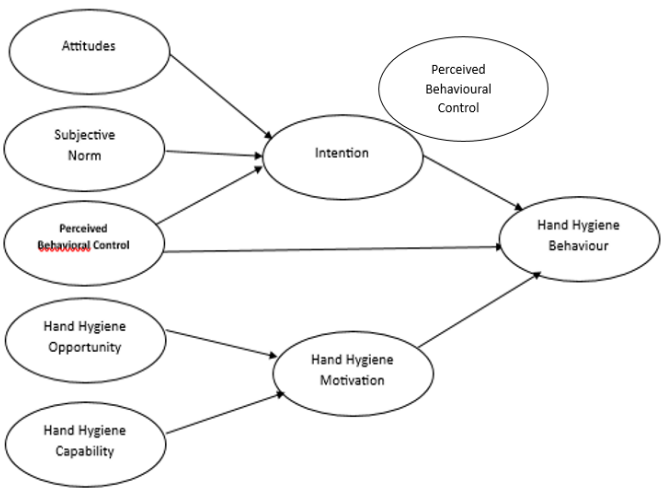

Figure 1. Conceptual framework
Modification: Sin et al, (2022); Gaube et al, (2021); Zheng et al, 2022)

This research model integrates the Theory of Planned Behavior (TPB) and contextual factors of hand hygiene to explain the determinants of hand hygiene behavior in healthcare workers. In this model, attitudes, subjective norms, and perceived behavioral control act as the main predictors of intention to perform hand hygiene according to WHO standards. Perceived behavioral control not only influences intention but also directly influences actual behavior. On the other hand, more specific work environment factors namely hand hygiene opportunity and hand hygiene capability are assumed to shape hand hygiene motivation, which then directly contributes to hand hygiene behavior. Thus, hand hygiene behavior is influenced by a combination of individual, social, and situational factors. The number of healthcare workers in the study was approximately 250, these healthcare workers working in healthcare facilities, thus allowing a comprehensive analysis of the determinants of hand hygiene behavior in a real clinical context.

Method

This study employed a quantitative explanatory approach using the Partial Least Squares–Structural Equation Modeling (PLS-SEM) analysis method. This approach was chosen because it aims to test causal relationships between complex latent variables, particularly when the study involves multiple mediating variables and reflective constructs. According to Hair et al. (2021), PLS-SEM is the most suitable approach for applied research in the fields of health management and organizational behavior because it can handle data with non-normal distributions, limited sample sizes, and focuses estimation on the variance of the construct being explained (variance-based estimation). Furthermore, this method is particularly useful in exploratory research contexts seeking to understand the relationship between ethical leadership, work empowerment, managerial competence, and trust in management in improving healthcare worker compliance with hand hygiene practices in hospitals.

Measurement

The research questionnaire consisted of two main sections. The first section contained demographic questions covering age, gender, profession (doctor, nurse, midwife, laboratory technician), length of service, and service unit (inpatient, outpatient, emergency department, or ICU). The second section measured the research variables using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

1. Attitude toward hand hygiene

The attitude toward hand hygiene variable was measured using an adaptation of an instrument from De Wandel et al. (2010), which is widely used in research on the determinants of hand hygiene compliance behavior in intensive care units. This construct stems from the Theory of Planned Behavior (TPB), which emphasizes that an individual's attitude toward a behavior influences intention and actual compliance. The original items assessed healthcare workers' positive and negative beliefs about the effectiveness, convenience, and moral value of hand hygiene. In this study, attitudes were operationalized through statements assessing perceived benefits, burdens, sense of responsibility, and professional values related to hand hygiene, including several reverse items to more accurately capture negative attitudes.

2. Subjective norms

The measurement of subjective norms refers to Sin and Rochelle (2022), who utilized the TPB to analyze how social pressure influences nurses' compliance with hand hygiene, particularly in the context of the COVID-19 pandemic. This construct describes the extent to which individuals perceive that important people in their work environment such as superiors, colleagues, and patients expect them to perform hand hygiene according to standards. The items used assess social expectations, social supervision, and the influence of coworkers in shaping collective norms of hand hygiene compliance.

3. Perceived Behavioral Control (PBC)

The perceived behavioral control variable was also adopted from Sin and Rochelle (2022), in line with the TPB concept, which views behavioral control as a key factor in shaping intentions and actual behavior. This instrument measures healthcare workers' perceptions of the ease, ability, and personal control in performing hand hygiene in various work conditions. The items used assess perceptions of resource availability, technical ability, and the ability to overcome situational barriers that may interfere with hand hygiene compliance.

4. Hand hygiene capability

The measurement of hand hygiene capability is derived from an instrument validated by Lydon et al. (2019), which assesses factors influencing healthcare workers' hand hygiene behavior in the context of intervention development. This construct emphasizes healthcare workers' technical ability, procedural knowledge, and confidence in correctly implementing hand hygiene practices. Items cover aspects of training, understanding of the WHO five moments, proficiency in performing proper handwashing, ability to explain procedures to others, and the application of behavioral automation.

5. Hand hygiene opportunity

The hand hygiene opportunity variable was also adapted from Lydon et al. (2019), who considered the opportunity to perform hand hygiene as a crucial contextual factor in their behavioral model. This instrument assesses the availability of facilities, ease of access, time availability, and the presence of visual reminders in the work environment. In addition to assessing facilities, the item also assesses the culture of compliance in the work unit, including the collegial behavior of nurses, doctors, and other healthcare workers as indicators of an environment conducive to hand hygiene.

6. Hand hygiene motivation

The hand hygiene motivation construct refers to the motivational scale from Lydon et al. (2019), which assesses intrinsic and extrinsic factors that encourage healthcare workers to perform hand hygiene. This motivation includes the perceived importance of compliance, encouragement from seniors or auditors, the habit of reminding each other within the work unit, and a sense of pride when compliance is recognized. This instrument is relevant in assessing the affective and social components that strengthen healthcare workers' internal drive to perform hand hygiene.

7. Intention to perform hand hygiene

The intention variable refers to Gaube et al. (2021), which examined hand hygiene intentions in patients and visitors using three behavioral theory models, including the TPB. Intention is seen as a direct predictor of behavior, reflecting an individual's commitment to performing hand hygiene according to guidelines. The items used measured healthcare workers' intentions to maintain compliance, increase hand hygiene frequency, serve as role models, and remind themselves and colleagues during various clinical procedures.

8. Hand hygiene behavior

Measurement of hand hygiene behavior refers to

WHO recommendations as well as behavioral items from studies such as Sax et al. (2007), which assesses actual compliance with the five moments of hand hygiene. This instrument assesses whether healthcare workers actually perform hand hygiene before and after patient contact, before aseptic procedures, after contact with body fluids, and after removing gloves. The items also measure the frequency of actual behavior and identify missed opportunities using reverse items.

Population and sample

The population of this study was all healthcare workers working at Dr. Hardjono Regional General Hospital, including doctors, nurses, midwives, laboratory personnel, and other clinical support staff who interact directly with patients. Due to time and access limitations, this study used a purposive sampling technique, with the following inclusion criteria: (1) healthcare workers who have worked for at least one year, (2) interact directly with patients in clinical activities, and (3) willing to volunteer as respondents.

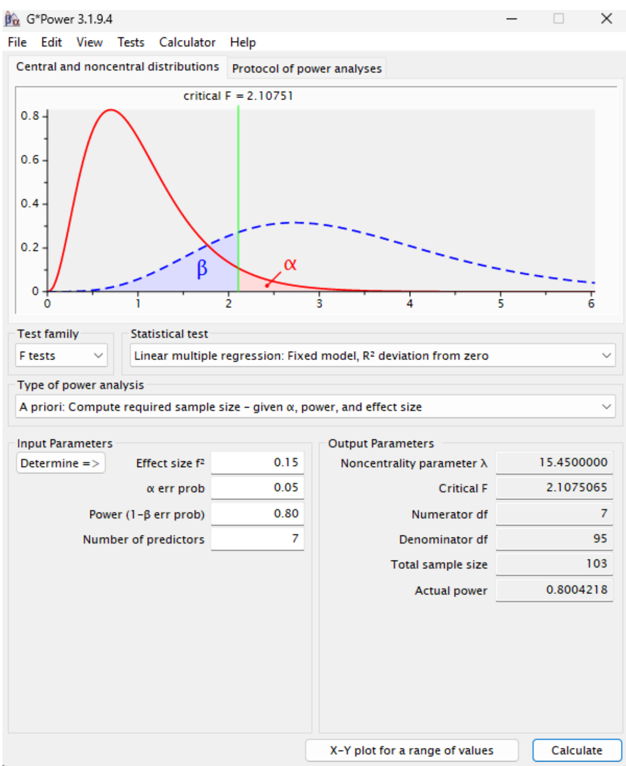

Figure 2. G*Power analysis

The calculation results using G*Power 3.1.9.4 with the F-test for multiple linear regression (fixed model, R^2 deviation from zero) show that by including an effect of $f^2 = 0.15$ (medium category), a significance level of $\alpha = 0.05$, and a test power of 0.80, a minimum sample size of 103 respondents is required for a model with 7 predictors. The resulting critical F value is 2.1075, with degrees of freedom for the numerator (df1 = 7) and the denominator (df2 = 95). The actual power value of 0.8004 confirms that this research design has met the minimum power limit of 0.80 which is generally recommended in quantitative research. Thus, a sample size of ≥103 is sufficient to detect the influence of predictor variables on the dependent variable in the multiple regression model to be tested.

Ethical research

This research has received ethical clearance from Harjono Regional Hospital. All research procedures were conducted in accordance with the principles of Good Clinical Practice (GCP) and the Declaration of Helsinki on the ethics of human research. Before completing the questionnaire, each respondent was provided with an informed consent form detailing the research objectives, benefits, potential risks, and guarantees of confidentiality of personal data. Participation in the research was voluntary, and respondents had the right to discontinue participation at any time without any consequences. All data was collected anonymously and used solely for academic purposes.

Furthermore, the researchers ensured that the questionnaire design and content did not contain questions that could cause discomfort or lead to a breach of privacy. The research results are reported in aggregate form without identifying any specific individuals or institutions. Data storage was securely conducted using a cloud-based storage system with access restricted only to the principal investigator.

Data analysis technique

The data analysis stage began with data cleaning to ensure there were no duplications or inconsistent answers. Next, descriptive analysis of respondent characteristics was conducted using frequency and percentage statistics. The next stage was model analysis using SmartPLS version 4 software, a PLS-SEM algorithm-based software program, as guided by

Hair et al. (2021).

An outer model analysis was conducted first to ensure that all indicators were valid and reliable. The inner model was then analyzed to test the research hypotheses, which included the relationships between latent variables. The path coefficient results were interpreted based on the β (beta) and p-values, while the model's explanatory power was assessed using the R^2 value. Furthermore, the f^2 value was used to measure the influence of each variable on the dependent variable, with an f^2 value of 0.02 considered small, 0.15 medium, and 0.35 large. To assess the model's predictive relevance, a Q^2 test was also conducted using the blindfolding technique, with positive values indicating good predictive ability.

An additional analysis, the Importance-Performance Map Analysis (IPMA), was used to provide more applicable managerial insights for hospitals. IPMA not only assesses the influence of variables on hand hygiene compliance but also identifies areas with low performance but high impact, thus prioritizing improvement by hospital management.

Result

Respondent profile

Table 1. Demographic characteristics of respondents (n = 300)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	105	35.0
	Female	195	65.0
Age	< 25 years	16	5.3
	25–34 years	138	46.0
	35–44 years	61	20.3
	≥ 45 years	85	28.3
Position	Physician	42	14.0
	Nurse	164	54.7
	Midwife	33	11.0
	Other healthcare workers	61	20.3
Length of Employment at RSUD dr. Hardjono	< 1 year	8	2.7
	1–5 years	104	34.7
	6–10 years	100	33.3
	> 10 years	88	29.3
Work Unit / Department	Inpatient ward	182	60.7
	Emergency department	34	11.3
	Outpatient clinic	24	8.0
	Intensive Care Unit (ICU)	23	7.7
	Laboratory	21	7.0
	Pharmacy unit	10	3.3
	Nutrition department	6	2.0

Based on data collected from 300 respondents, the majority of respondents in this study were female (65.0%), while male respondents accounted for 35.0%. In terms of age, the majority of respondents were in the 25–34 age group (46.0%), followed by those aged 45 years and older (28.3%) and those aged 35–44 years (20.3%), while respondents under 25 comprised the smallest group (5.3%). This indicates that respondents were predominantly productive-age healthcare workers with relatively extensive work experience.

In terms of job title, the majority of respondents were nurses (54.7%), followed by other medical personnel (20.3%), doctors (14.0%), and midwives (11.0%). This composition reflects the hospital's human resource structure, which is dominated by nursing staff as the frontline of patient care. Based on length of service, respondents with 1–5 years of service (34.7%) and 6–10 years (33.3%) dominated the study sample, followed by respondents with more than 10 years of service (29.3%), indicating that most respondents had sufficient work experience in hospitals.

Furthermore, based on the unit or room where they worked, the majority of respondents came from the inpatient unit (60.7%), followed by the Emergency Department (11.3%), outpatient department (8.0%), ICU (7.7%), and laboratory (7.0%), while other units, such as the pharmacy depot and nutrition department, accounted for a smaller proportion. This distribution indicates that most respondents work in units with high levels of direct patient contact, making it relevant to the research focus on healthcare workers' hand hygiene practices.

Outer model

The outer model is a measurement model that explains the relationship between a latent construct and its indicators. The outer model is used to ensure that the indicators accurately measure the intended construct. Its evaluation includes validity tests (e.g., outer loading, AVE) and reliability tests (e.g., CR). In other words, the outer model answers the question: "Is the measurement instrument used valid and reliable?" The following are the results of this research's outer model:

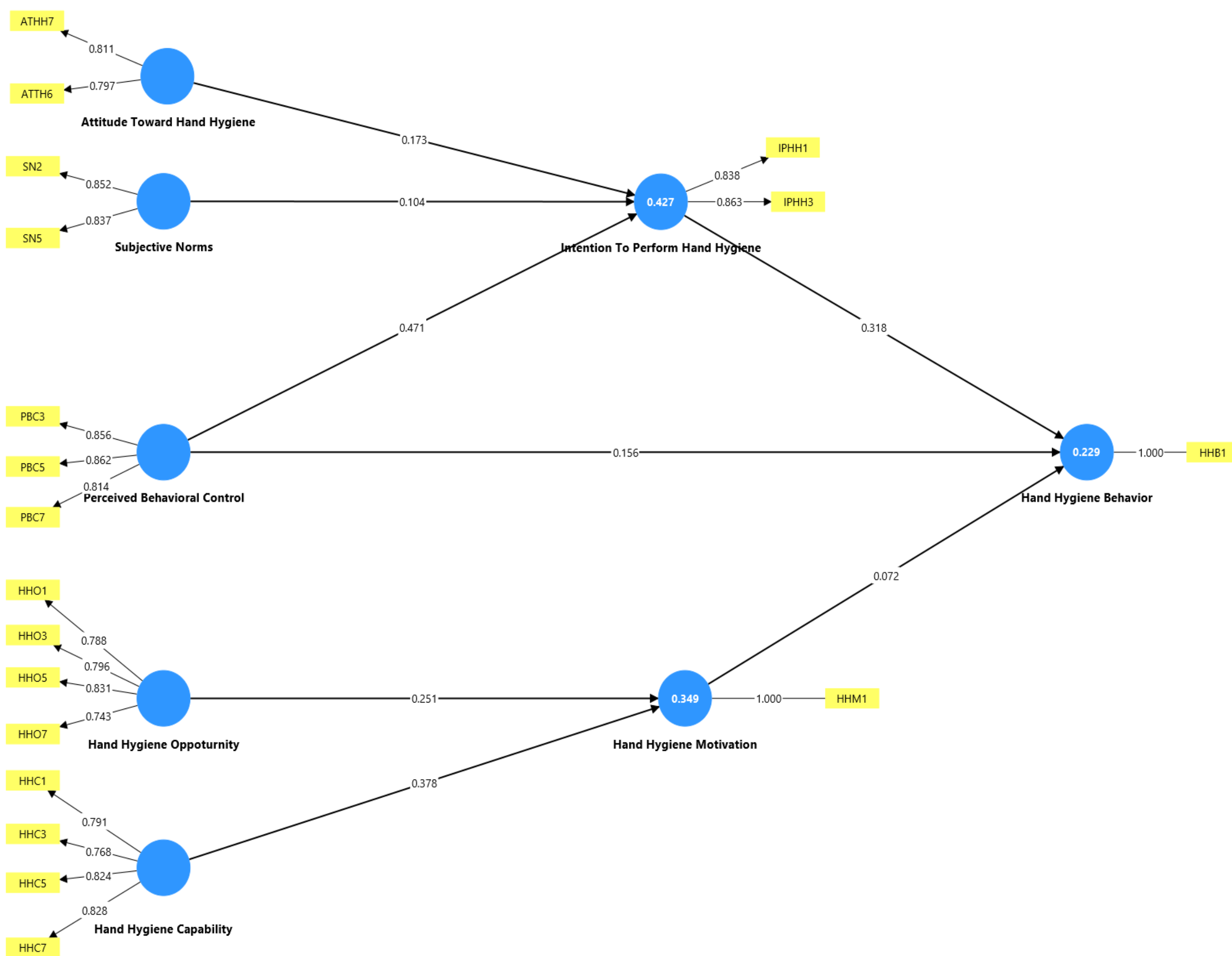

Figure 2. Outer model

Table 2. Evaluation of measurement model (outer model)

Construct and Item	Outer loadings
Attitude Toward Hand Hygiene (AVE=0,646, CR=0,785)	
ATTH7 I feel satisfied when I can maintain compliance with hand hygiene	0,811
ATTH6 Hand hygiene is my moral responsibility towards patient safety	0,797
Hand Hygiene Behavior (Outer loadings 1.000 single-item construct)	
HHB1 I always perform hand hygiene before contact with patients.	1,000
Hand Hygiene Capability (AVE =0,645, CR=0,879)	
HHC1 I have received adequate training on hand hygiene practices in this unit.	0,791
HHC3 I know how to properly wash my hands.	0,768
HHC5 I find it easy to follow the hand hygiene recommendations in this unit.	0,824
HHC7 I feel confident in implementing standard hand hygiene practices in all clinical situations.	0,828
Hand Hygiene Motivation (Outer loadings 1.000 single-item construct)	
HHM1 Hand hygiene compliance is considered important by staff in this unit.	1,000
Hand Hygiene Oppoturnity (AVE=0,624, CR=0,869)	
HHO1 I have enough time to perform hand hygiene while working.	0,788
HHO3 Nurses in this unit always perform hand hygiene when needed.	0,796
HHO5 Medical visitors in this unit always perform hand hygiene as needed.	0,831
HHO7 Reminders (such as posters) are available to encourage staff to perform hand hygiene.	0,743
Intention To Perform Hand Hygiene (AVE=0,723, CR=0,840)	
IPHH1 I intend to always practice hand hygiene according to WHO guidelines.	0,838
IPHH3 I am committed to maintaining hand hygiene compliance in all clinical procedures.	0,863
Perceived Behavioral Control (AVE=0,713, CR=0,881)	
PBC3 I have complete control over my hand hygiene practices.	0,856
PBC5 I am confident in maintaining hand hygiene adherence in any situation.	0,862
PBC7 I am able to overcome barriers that may prevent me from practicing hand hygiene.	0,814
Subjective Norms (AVE=0,714, CR=0,833)	
SN2 My colleagues expect me to practice hand hygiene according to established protocols.	0,852
SN5 Influential people in my profession support adherence to hand hygiene.	0,837

The results of the measurement model evaluation indicate that most of the constructs in this study meet the criteria for convergent validity and internal reliability. The Attitude Toward Hand Hygiene construct had an AVE value of 0.646 and a Composite Reliability (CR) of 0.785, indicating adequate levels of convergent validity and reliability. All indicators within this construct had outer loading values above 0.70, thus valid in representing the construct being measured.

The Hand Hygiene Capability construct also demonstrated good measurement quality with an AVE value of 0.645 and a CR of 0.879. The outer loading values of the indicators ranged from 0.768 to 0.828, indicating that each indicator adequately explained the construct's variance. A similar finding was demonstrated by the Hand Hygiene Opportunity construct, with an AVE value of 0.624 and a CR of 0.869, and outer indicator loadings ranging from 0.743 to 0.831, meeting convergent validity and reliability criteria.

Furthermore, the Intention to Perform Hand Hygiene construct had an AVE value of 0.723 and a CR of 0.840, with outer indicator loadings of 0.838 and 0.863, respectively, indicating strong convergent validity. The Perceived Behavioral Control construct also demonstrated excellent results, with an AVE value of 0.713 and a CR of 0.881, and outer indicator loadings ranging from 0.814 to 0.862. Similarly, the Subjective Norms construct had an AVE value of 0.714 and a CR of 0.833, with all indicators having outer loadings above 0.80, indicating adequate reliability and validity.

Meanwhile, the Hand Hygiene Behavior and Hand Hygiene Motivation constructs were each measured using a single-item indicator with an outer loading of 1.000. Therefore, internal reliability and convergent validity tests, such as AVE and CR, were not conducted on these two constructs because they are not relevant for constructs with a single indicator. The use of a single indicator for these two constructs was based on the theoretical consideration that the indicator directly represents the concept being measured.

Overall, the results of the measurement model evaluation indicate that all constructs in this study, both those measured using single and multiple indicators, met the criteria for measurement model feasibility and could be used for further structural model analysis.

Inner model

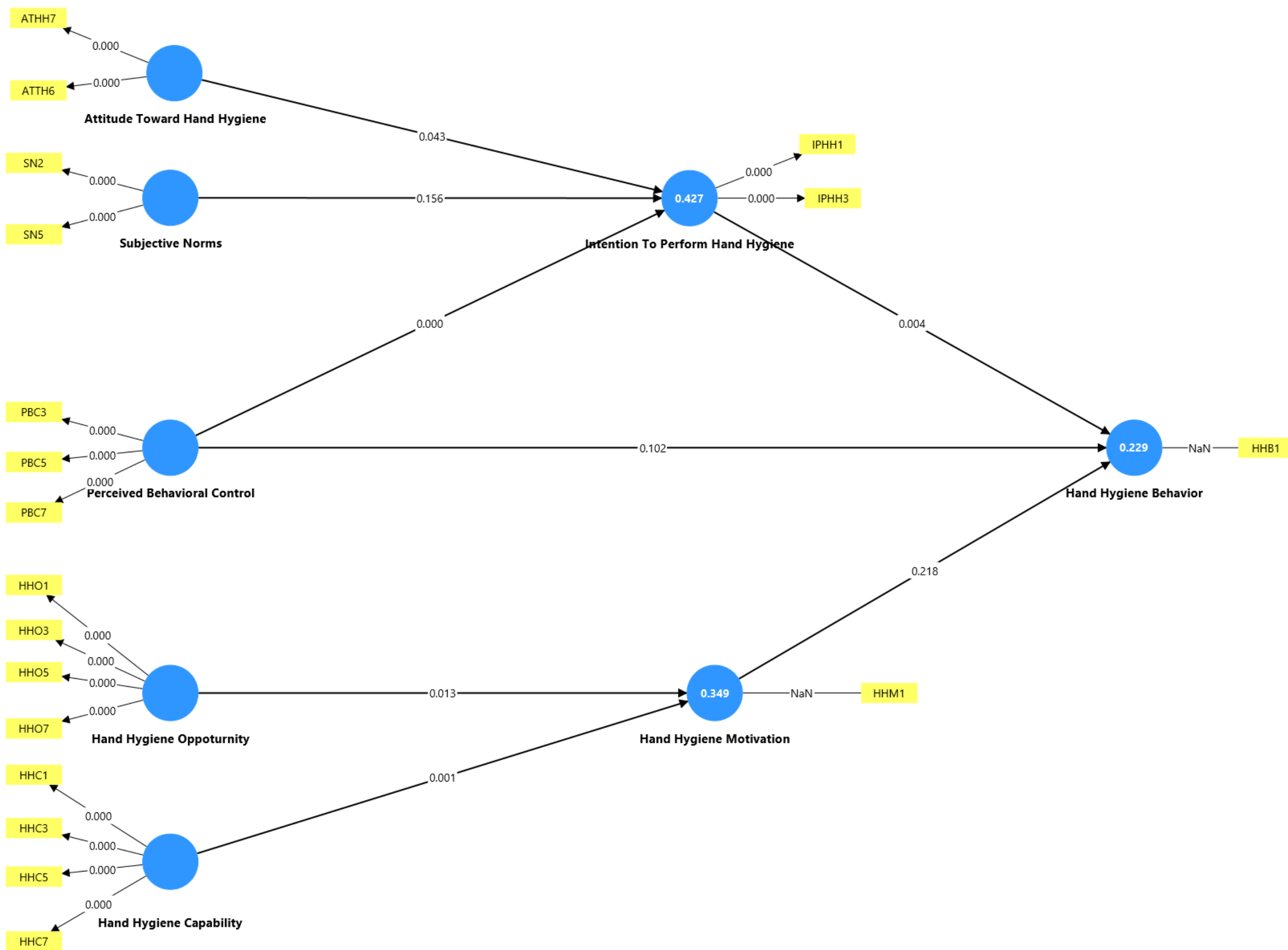

Figure 3. Inner model

The inner model is a structural model that explains the relationships between latent constructs in the research. The inner model is used to test hypotheses and the influences between variables, as well as to assess the model's ability to explain and predict the phenomena under study. The evaluation includes path coefficients, R-square, and the model's predictive ability. The inner model answers the question: "Is the relationship between the variables in the research model proven?" The following are the results of this research's inner model:

Table 3. R-square

	R-square
Hand Hygiene Behavior	0,229
Hand Hygiene Motivation	0,349
Intention To Perform Hand Hygiene	0,427

The structural model evaluation results showed an R-square (R^2) value for the Hand Hygiene Behavior construct of 0.229, meaning that 22.9% of the variation in hand hygiene behavior can be explained by the independent constructs in the research model. This value indicates a weak to moderate level of model explanatory power.

Furthermore, the Hand Hygiene Motivation construct had an R-square value of 0.349, indicating that 34.9% of the variation in hand hygiene motivation can be explained by the predictor variables in the model. This value indicates the model's moderate predictive power.

Meanwhile, the Intention to Perform Hand Hygiene construct obtained an R-square value of 0.427, meaning that 42.7% of the variation in intention to perform hand hygiene can be explained by the exogenous constructs that influence it. This value indicates that the model has moderate to strong explanatory power for the intention construct.

Overall, the R-square results indicate that the structural model built has sufficient explanatory power, although there are still other variables outside the model that have the potential to influence behavior, motivation, and intention in performing hand hygiene.

Table 4. CVPAT

Variable	PLS Loss	IA Loss	Avg. Loss Diff (IA)	t-value (IA)	p-value (IA)	LM Loss	Avg. Loss Diff (LM)	t-value (LM)	p-value (LM)
Hand Hygiene Behavior	0,070	0,082	-0,012	1,396	0,164	0,079	-0,009	1,596	0,112
Hand Hygiene Motivation	0,068	0,100	-0,032	3,251	0,001	0,084	-0,016	3,298	0,001
Intention To Perform Hand Hygiene	0,074	0,099	-0,026	2,279	0,023	0,078	-0,005	0,806	0,421
Overall Model	0,071	0,095	-0,024	2,806	0,005	0,080	-0,009	2,385	0,018

The results of the Cross-Validated Predictive Ability Test (CVPAT) show that the PLS-SEM model generally has better predictive ability compared to the Indicator Average (IA) and Linear Model (LM). This is indicated by the negative average loss difference value for all constructs and the overall model, indicating that the PLS-SEM prediction error is smaller than the comparison model. Specifically, for the Hand Hygiene Motivation construct, the PLS-SEM model was proven to be significantly superior to the IA and LM, with a p-value of 0.001 each, indicating strong predictive ability. For the Intention to Perform Hand Hygiene construct, PLS-SEM has better predictive ability than the IA ($p = 0.023$), but not significantly different from the LM ($p = 0.421$). Meanwhile, for the Hand Hygiene Behavior construct, the difference in predictive ability between PLS-SEM and IA and LM was not significant ($p > 0.05$), although the average loss difference value still showed the superiority of PLS-SEM. Overall, the CVPAT results at the model level showed that PLS-SEM had significant and better predictive ability than the two comparison models (IA: $p = 0.005$; LM: $p = 0.018$), so it can be concluded that this research model has adequate to strong predictive validity.

Table 5. Hypothesis testing

Hypothesis	Path	Original Sample (O)	Sample Mean (M)	STDEV	T-Statistics	P-Values	Result
H1	Attitude Toward Hand Hygiene on Intention To Perform Hand Hygiene	0,173	0,176	0,101	1,715	0,043	Accepted
H2	Subjective Norms on Intention To Perform Hand Hygiene	0,104	0,112	0,102	1,013	0,156	Rejected
H3	Perceived Behavioral Control	0,471	0,466	0,103	4,556	0,000	Accepted

	on Intention To Perform Hand Hygiene						
H4	Hand Hygiene Opportunity on Hand Hygiene Motivation	0,251	0,255	0,113	2,230	0,013	Accepted
H5	Hand Hygiene Capability on Hand Hygiene Motivation	0,378	0,384	0,117	3,241	0,001	Accepted
H6	Intention To Perform Hand Hygiene on Hand Hygiene Behavior	0,318	0,323	0,118	2,685	0,004	Accepted
H7	Perceived Behavioral Control on Hand Hygiene Behavior	0,156	0,158	0,123	1,268	0,102	Rejected
H8	Hand Hygiene Motivation on Hand Hygiene Behavior	0,072	0,069	0,093	0,779	0,218	Rejected

Based on hypothesis testing above the result state that:

H1: Attitude on Intention to Perform Hand Hygiene

The test results show that attitude toward hand hygiene has a positive effect on intention to perform hand hygiene, with a path coefficient of 0.173, a t-statistic of 1.715, and a p-value of 0.043. A p-value less than 0.05 indicates statistical significance. Therefore, hypothesis H1 is accepted, meaning that healthcare workers' positive attitudes toward hand hygiene can increase their intention to consistently practice hand hygiene.

H2: Subjective Norms on Intention to Perform Hand Hygiene

Hypothesis testing indicates that subjective norms do not have a significant effect on intention to perform hand hygiene. This is indicated by a path coefficient of 0.104, a t-statistic of 1.013, and a p-value of 0.156, which is greater than the 0.05 significance level. Therefore, hypothesis H2 is rejected. These findings indicate that social pressure or expectations from the work environment are not strong enough to influence healthcare workers' intention to perform hand hygiene.

H3: Perceived Behavioral Control on Intention to Perform Hand Hygiene

The analysis results show that perceived behavioral control has a positive and significant effect on intention to perform hand hygiene, with a path coefficient of 0.471, a t-statistic of 4.556, and a p-value of 0.000. Therefore, hypothesis H3 is accepted. This finding indicates that the higher healthcare workers' perceptions of their ability and self-control in performing hand hygiene, the stronger their intention to practice hand hygiene.

H4: Hand Hygiene Opportunity on Hand Hygiene Motivation

The test results indicate that hand hygiene opportunity has a positive and significant effect on hand hygiene motivation, with a path coefficient of 0.251, a t-statistic of 2.230, and a p-value of 0.013. Therefore, hypothesis H4 is accepted. These findings indicate that time availability, environmental support, and adequate facilities can increase healthcare workers' motivation to perform hand hygiene.

H5: Hand Hygiene Capability on Hand Hygiene Motivation

The analysis results show that hand hygiene capability has a positive and significant effect on hand hygiene motivation, with a path coefficient of 0.378, a t-statistic of 3.241, and a p-value of 0.001. Therefore, hypothesis H5 is accepted. This indicates that healthcare workers' ability, knowledge, and skills in performing hand hygiene play a significant role in increasing their motivation to adhere to hand hygiene practices.

H6: Intention to Perform Hand Hygiene on Hand Hygiene Behavior

Hypothesis testing shows that intention to perform hand hygiene has a positive and significant effect on hand hygiene behavior, with a path coefficient of 0.318, a t-statistic of 2.685, and a p-value of 0.004. Therefore, hypothesis H6 is accepted. These findings confirm that strong intentions are an important predictor of healthcare workers' actual hand hygiene behavior.

H7: Perceived Behavioral Control on Hand Hygiene Behavior

The analysis results show that perceived behavioral control does not significantly influence hand hygiene behavior. This is indicated by a path coefficient of 0.156, a t-statistic of 1.268, and a p-value of 0.102, all greater than 0.05. Therefore, hypothesis H7 is rejected. This finding indicates that although healthcare workers perceive control over hand hygiene practices, this perception has not yet directly translated into actual behavior.

H8: Hand Hygiene Motivation on Hand Hygiene Behavior

The test results indicate that hand hygiene motivation does not significantly influence hand hygiene behavior, with a path coefficient of 0.072, a t-statistic of 0.779, and a p-value of 0.218. Therefore, hypothesis H8 is rejected. These findings suggest that motivation alone is not sufficient to encourage hand hygiene behavior, possibly due to other factors such as work habits, workload, or situational conditions influencing actual behavior.

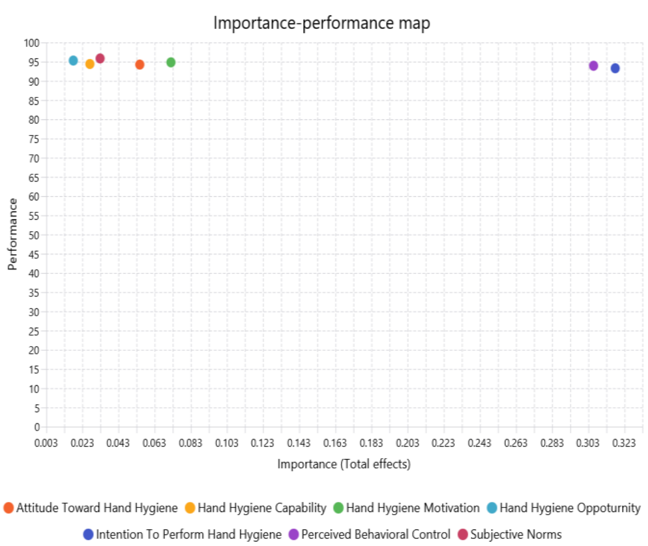

Figure 4. IPMA map

The Importance–Performance Map Analysis (IPMA) results show that the constructs Intention to Perform Hand Hygiene and Perceived Behavioral Control have the highest importance on hand hygiene behavior, with total effects of 0.318 and 0.306, respectively. These findings indicate that these two constructs are the most influential key factors in shaping healthcare workers' hand hygiene behavior. However, the performance scores for these two constructs are relatively lower than the other constructs, with Intention and Perceived Behavioral Control scoring 93.290 and 93.941, respectively. This indicates room for improvement in both constructs to effectively improve hand hygiene behavior.

Meanwhile, other constructs, such as Hand Hygiene Motivation, Attitude Toward Hand Hygiene, Subjective Norms, Hand Hygiene Capability, and Hand Hygiene Opportunity, showed relatively lower total effects, ranging from 0.018 to 0.072, despite their high performance scores (above 94). This indicates that although healthcare workers' perceptions of attitudes, subjective norms, capabilities, opportunities, and motivation toward hand hygiene are at a good level, their contribution to improving hand hygiene behavior is relatively limited compared to intentions and perceived behavioral control.

Overall, the IPMA results indicate that the primary priority for interventions to improve hand hygiene behavior should focus on improving Intention to Perform Hand Hygiene and Perceived Behavioral Control, as these two constructs have the greatest influence but relatively suboptimal performance. Interventions that emphasize strengthening intentions and increasing a sense of control, such as reducing situational barriers and strengthening behavioral commitment, have the potential to have a more significant impact on improving healthcare workers' hand hygiene compliance.

Discussion

The results of this study confirm that intention and perceived behavioral control are the primary determinants in shaping healthcare workers' hand hygiene behavior. This finding is consistent with the Theory of Planned Behavior, which states that preventive behavior in the healthcare professional context is primarily driven by strong intentions and perceived control over those behaviors. A study by Sin and Rochelle (2022) on nurses in Hong Kong during the COVID-19 pandemic demonstrated that intention plays a central role in driving hand hygiene compliance, even in high-stress work situations. This finding also aligns with Ojanperä et al. (2020), who demonstrated that healthcare workers' hand hygiene compliance directly contributed to the reduction of healthcare-associated infections.

The influence of attitude on intention indicates that healthcare workers' positive evaluations of hand hygiene both as a professional obligation and as a form of responsibility for patient safety remain an important foundation in shaping behavioral intentions. This finding is supported by Gaube et al. (2021), who emphasized that cognitive and affective attitudes toward hand hygiene play a role in building an individual's readiness to act, although attitude alone is not always sufficient to ensure actual behavior. In this context, attitudes serve as psychological prerequisites that strengthen intentions, rather than as direct drivers of behavior.

Conversely, the insignificance of subjective norms suggests that social pressure or expectations from colleagues and the professional environment are not dominant factors in shaping healthcare workers' intentions. This finding aligns with Haenen et al. (2022), who found that in clinical settings, hand hygiene is often an established professional norm, making explicit social influences less salient. In other words, healthcare workers tend to rely on internal assessments and perceived self-control rather than social incentives to determine hand hygiene behavior.

The strong role of perceived behavioral control on intentions and behavior suggests that the perceived ability to overcome situational barriers such as limited time, workload, or access to facilities is crucial to hand hygiene practice. This finding is supported by Du et al. (2021), who highlighted that the challenge of nosocomial infections during the COVID-19 pandemic requires healthcare workers to have a high sense of control to maintain adherence to hand hygiene protocols. Ambrosch et al. (2020) also demonstrated that the implementation of a strict hygiene bundle, which reduced structural barriers, significantly improved hand hygiene compliance in hospitals.

From the COM-B model perspective, the results of this study indicate that capability and opportunity play a significant role in increasing motivation, but this motivation does not automatically translate into hand hygiene behavior. This finding is consistent with Zheng et al. (2022), who emphasized that even when healthcare workers have adequate knowledge and skills and are highly motivated, actual behavior remains strongly influenced by situational control and strong intentions. A study by Sithole et al. (2024) also showed that training and clinical protocols need to be accompanied by work system support to have an impact on actual practice.

The IPMA results provide practical implications that reinforce the findings of the hypothesis testing. Although constructs such as attitudes, subjective norms, capability, opportunity, and motivation demonstrated high levels of performance, their contribution to improving hand hygiene behavior was relatively smaller than intention and perceived behavioral control. These findings suggest that interventions that focus solely on education, training, or increasing motivation without strengthening intention and behavioral control are potentially less effective. This aligns with the cost and efficiency analyses of nosocomial infection prevention interventions presented by Tchouaket et al. (2021) and Nguemeleu et al. (2020, 2022), which emphasize the importance of a systemic and priority-based approach to infection control.

Overall, this discussion suggests that improving hand hygiene behavior among healthcare workers requires a more targeted approach focused on strengthening intentions and increasing perceived behavioral control, supported by a work environment that minimizes operational barriers. These findings enrich the literature on hand hygiene behavior by integrating the TPB and COM-B perspectives, and provide an empirical basis for formulating more effective policies and interventions for preventing nosocomial infections in healthcare facilities.

Conclusion

This study concluded that healthcare workers' hand hygiene behavior was primarily influenced by their intention to practice hand hygiene and perceived behavioral control, which reflects the extent to which healthcare workers feel capable and in control of implementing hand hygiene practices in the workplace. Positive attitudes toward hand hygiene were shown to play a role in shaping intention, while subjective norms were not a dominant factor in the healthcare professional context. Furthermore, ability and opportunity contribute to increasing motivation, but motivation does not directly translate into actual behavior without strong intentions and adequate perceptions of control. These findings emphasize that improving hand hygiene compliance cannot rely solely on education and motivation; instead, an approach that simultaneously strengthens psychological and structural aspects is required. Overall, the integration of the Theory of Planned Behavior and the COM-B model in this study provides a comprehensive understanding of the key factors shaping healthcare workers' hand hygiene behavior.

Based on the study's findings, healthcare facility management is advised to prioritize interventions focused on strengthening healthcare workers' intentions and increasing perceived behavioral control. These efforts can be achieved through streamlining workflows, reducing situational barriers such as limited time and facility access, and providing easily accessible hand hygiene facilities at every service point. Furthermore, training programs should not only emphasize knowledge and skills, but also focus on fostering professional commitment and a sense of control in various work settings. A systems-based approach, such as consistent protocol implementation, leadership support, and a culture of patient safety, is expected to create a work environment conducive to sustainable and effective hand hygiene practices in preventing nosocomial infections.

Further research is recommended to explore other factors beyond the model used in this study, such as workload, fatigue, clinical leadership, and organizational culture, which potentially influence healthcare workers' hand hygiene behavior. Furthermore, the use of longitudinal designs or direct observational methods can provide a deeper understanding of the gap between intentions and actual behavior. Future research could also consider a mixed-methods approach to qualitatively explore healthcare workers' experiences and perceptions of barriers and facilitators to hand hygiene practice. Thus, the results of this follow-up study are expected to provide a more comprehensive contribution to designing effective and sustainable interventions to improve hand hygiene compliance in various healthcare contexts.

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