Health Problems of Civilization
eISSN: 2354-0265, ISSN: 2353-6942

ORIGINAL PAPER

Hand hygiene beliefs and self-reported practices among health profession students: a cross-sectional study

Dursun Alper Yılmaz[1(A,C,D,E)], **Mehmet Emin Atay**[2(A,B,C,D,E)], **Gökhan Dege**[1(A,C,D,F)], **Mustafa Özkan Fırat**[3(B,E)], **Mehmet Salih Yıldırım**[1(B,F)], **Volkan Gökmen**[1(C,E)]

[1]Faculty of Health Sciences, Ağrı İbrahim Çeçen University, Ağrı, Türkiye

[2]Faculty of Health Sciences, Mardin Artuklu University, Mardin, Türkiye

[3]Vocational School of Health Services, Ağrı İbrahim Çeçen University, Ağrı, Türkiye

Yılmaz DA, Atay ME, Dege G, Fırat MÖ, Yıldırım MS, Gökmen V. Hand hygiene beliefs and self-reported practices among health profession students: a cross-sectional study. Health Prob Civil. https://doi.org/10.29316/hpc/237539

Tables: 4
Figures: 1
References: 25
Submitted: 2026 Aug 21
Accepted: 2026 Sep 16

Address for correspondence: Dursun Alper Yılmaz, Faculty of Health Sciences, Ağrı İbrahim Çeçen University, A Block, Erzurum Boulevard, 04100 Merkez, Ağrı, Türkiye, e-mail: dayilmaz@agri.edu.tr
ORCID: Dursun Alper Yılmaz https://orcid.org/0000-0001-8096-5504, Mehmet Emin Atay https://orcid.org/0000-0002-5373-9031, Gökhan Dege https://orcid.org/0000-0001-9237-770X, Mustafa Özkan Fırat https://orcid.org/0000-0001-6556-7575, Mehmet Salih Yıldırım https://orcid.org/0000-0003-2632-4583, Volkan Gökmen https://orcid.org/0000-0001-6490-8913

Abstract

Background. Hand hygiene is essential for infection prevention, yet self-reported practices may be influenced by individual beliefs and previous training. This study examined the relationship between hand hygiene beliefs and self-reported practices among health profession students.

Material and methods. This cross-sectional analytical study included 432 students enrolled in Nursing, Nutrition and Dietetics, First Aid and Emergency Care, and Elderly Care programs at a state university in Eastern Anatolia, Türkiye. Data were collected using a sociodemographic questionnaire, the Hand Hygiene Belief Scale (HHBS), and the Hand Hygiene Practice Inventory (HHPI). Group comparisons, Spearman correlation, and exploratory path analysis were performed.

Results. Mean HHBS and HHPI scores were 80.23±13.64 and 63.46±9.31, respectively. Female students had higher HHBS and HHPI scores than males (p<0.05). Prior hand hygiene training was associated with higher HHBS scores (p<0.05). HHPI scores differed by academic year (p<0.01). HHBS and HHPI scores were weakly positively correlated (r=0.275, p<0.001). A small statistical indirect association between prior training and HHPI through HHBS was observed (β=0.06, 95% CI: 0.028-0.099).

Conclusions. Stronger hand hygiene beliefs were associated with more frequent self-reported practices, although the observed associations were modest and should not be interpreted causally.

Keywords: hygiene beliefs, health profession students, health belief model, hygiene practices, hand hygiene

Introduction

Hand hygiene remains a core infection-prevention behavior in health care, and students entering clinical environments need to develop reliable hand hygiene habits before independent practice. A recent global scoping review found that health profession students generally expressed positive attitudes toward hand hygiene, while important gaps in knowledge and practice persisted [1]. A large 2025 study of health sciences students in Türkiye similarly showed that hand hygiene beliefs and practices varied across student characteristics and prior educational exposure [2].

Educational stage and clinical exposure may influence hand hygiene competence. Nursing students at the end of training demonstrated greater hand hygiene knowledge than first-semester students in a recent comparative study [3], while a 2026 survey found that students placed substantial importance on education, availability of hand-rub products, and supportive leadership [4]. Studies among medical and paramedical students likewise continue to identify incomplete knowledge and variable practice despite generally favorable attitudes [5,6]. These findings indicate that hand hygiene education should be treated as a longitudinal competency rather than a single instructional event.

Hand hygiene behavior is also shaped by contextual and individual determinants. Recent multicenter and hospital-based studies have associated compliance or knowledge with factors including gender, training, professional role, institutional support, workload, and availability of supplies [7-10]. Such findings are relevant to students because clinical learning occurs within the same organizational environments in which professional behaviors are modeled and reinforced.

Cognitive theories provide a useful framework for examining why educational exposure may not correspond directly with hand hygiene behavior. The Theory of Planned Behavior emphasizes attitudes, perceived behavioral control, and intention as determinants of behavior [11], whereas the Health Belief Model highlights perceived susceptibility, severity, benefits, barriers, and related beliefs [12]. Within hand hygiene education, these frameworks suggest that educational exposure, beliefs, and self-reported hand hygiene practices may be interrelated rather than operating as isolated determinants.

Despite the growing literature on hand hygiene among health profession students, important gaps remain. Much of the existing evidence has been descriptive, focusing primarily on knowledge, attitudes, practices, or differences according to demographic and educational characteristics. Recent studies, including research among health sciences students in Türkiye, have demonstrated associations between educational exposure and hand hygiene beliefs or practices [1-6]; however, less attention has been given to how these factors are statistically related within a theory-informed path model. In particular, it remains unclear whether the association between previous hand hygiene training and self-reported practice is accompanied by an indirect association through students' hand hygiene beliefs. Examining these relationships may provide a more integrated understanding of the cognitive and educational factors associated with self-reported hand hygiene behavior. Given the cross-sectional design, such modeling

cannot establish temporal or causal mediation but can identify statistical indirect associations that may inform hypotheses for subsequent longitudinal and intervention studies.

Aim of the work

The primary aim of this study was to examine the association between hand hygiene beliefs and self-reported hand hygiene practices among health profession students and to determine whether these outcomes differed according to gender, academic year, and previous hand hygiene training. A secondary, exploratory aim was to examine whether previous hand hygiene training showed a statistical indirect association with self-reported hand hygiene practice through hand hygiene beliefs within the specified path model.

Material and methods

Study design and setting

This analytical cross-sectional study was conducted from October 2023 to November 2024 at Ağrı İbrahim Çeçen University in the Eastern Anatolia region of Türkiye. The participants were enrolled in the Faculty of Health Sciences, the Vocational School, or the Vocational School of Health Services. The study focused on students in Nursing, Nutrition and Dietetics, First Aid and Emergency Care, and Elderly Care programs.

Population and sampling

The source population comprised 568 students aged 18 years or older who were actively enrolled in Nursing, Nutrition and Dietetics, First Aid and Emergency Care, and Elderly Care programs at Ağrı İbrahim Çeçen University during the study period. All 568 eligible students were invited to participate; however, the participants were ultimately enrolled through voluntary non-probability sampling. Eligibility criteria were enrollment in one of the specified programs, age ≥18 years, and provision of electronic informed consent.

A total of 432 students accessed and completed the online questionnaire, yielding a response rate of 76.1%. All the students who initiated the questionnaire completed it, and no questionnaires were excluded from the final analysis. Accordingly, the final analytic sample consisted of 432 participants.

An a priori sample-size calculation was performed using G*Power 3.1 [13] for a planned one-way ANOVA comparing the four academic-year groups. Assuming a small-to-moderate effect size (Cohen's f=0.20), α=0.05, statistical power of 0.95, and four independent groups, the estimated required total sample size was 434 participants. The final analytic sample of 432 participants was therefore slightly below the calculated target. This calculation was intended to support the planned between-group analyses and was not based on a separately designated primary outcome. The path analysis was a secondary, exploratory component of the study and was not used as the basis for the original a priori sample-size calculation.

Data collection instruments

Data were collected through an online structured questionnaire. The sociodemographic form consisted mainly of closed, single-response items addressing age, gender, perceived economic status, place of residence, academic program, year of study, prior hand hygiene training, and the participant's perceived primary reason for poor hand hygiene compliance.

Prior hand hygiene training was assessed using a single self-reported binary item asking whether the participant had previously received formal hand hygiene training (yes/no). No additional information was collected regarding the format of the training (e.g. lecture, practical session, or clinical-placement instruction), its timing, duration, frequency, content, or training provider. Accordingly, this variable represents self-reported previous exposure to formal hand hygiene training rather than a standardized or independently verified educational intervention.

The Hand Hygiene Belief Scale (HHBS) was originally developed as part of the Hand Hygiene Questionnaire for healthcare students [14] and subsequently used in the Turkish context by Karadag et al. [15]. The HHBS contains 22 items rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), yielding total scores from 22 to 110; higher scores indicate stronger hand hygiene beliefs. The Turkish application reported a Cronbach's α of 0.76

[15]. In the present study, the HHBS demonstrated acceptable internal consistency (Cronbach's α=0.76).

The Hand Hygiene Practice Inventory (HHPI) contains 14 items assessing the self-reported frequency of hand hygiene behavior in different situations. Responses range from 1 (never) to 5 (always), with total scores ranging from 14 to 70; higher scores indicate more frequent self-reported hand hygiene practices. The Turkish application reported a Cronbach's α of 0.85 [15]. In the present study, the HHPI demonstrated acceptable internal consistency (Cronbach's α=0.74). The HHPI reflects participants' self-reported practices and should not be interpreted as an objective measure of directly observed hand hygiene compliance.

Data collection procedure

Students were invited through institutional e-mail and course-specific WhatsApp groups. The questionnaire was administered using Google Forms. Electronic informed consent was obtained before the questionnaire opened, and completion took approximately 10-15 minutes. Responses were anonymous, and participation was voluntary.

Statistical analysis

Analyses were performed using IBM SPSS Statistics version 26.0 and IBM SPSS AMOS version 24.0. Continuous variables are presented as mean±standard deviation (SD), and categorical variables as number and percentage. Distributional assumptions were evaluated using the Shapiro-Wilk test together with visual inspection of histograms and Q-Q plots. Statistical significance was set at α=0.05. Independent-samples t tests and one-way analysis of variance (ANOVA) were used for group comparisons when parametric assumptions were considered acceptable; non-parametric alternatives were planned when these assumptions were not met. Tukey HSD or Bonferroni-adjusted post-hoc comparisons were used following significant omnibus tests, as appropriate. Effect sizes were reported for group comparisons using Cohen's d for two-group comparisons and η^2 for one-way ANOVA comparisons to complement statistical significance testing and facilitate interpretation of the magnitude of group differences. Spearman's rank correlation was used to assess the association between HHBS and HHPI scores.

A secondary, exploratory observed-variable path model within the structural equation modeling framework was fitted to examine the hypothesized relationships among previous hand hygiene training, hand hygiene beliefs, and self-reported hand hygiene practice. Specifically, the model evaluated whether previous training showed a statistical indirect association with HHPI through HHBS. Previous hand hygiene training was specified as the focal exogenous exposure, HHBS as the intermediate variable, and HHPI as the outcome. Gender and academic year were included as exogenous covariates because both variables were directly relevant to the study objectives and have been associated with hand hygiene beliefs or practices in previous literature. Other measured characteristics were not added solely on the basis of their observed associations in the present dataset in order to avoid unnecessary post hoc model expansion.

Maximum likelihood estimation was used, and the statistical indirect association was evaluated using 2,000 bias-corrected bootstrap samples with 95% confidence intervals. Model fit was assessed using χ^2/df, the root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR), according to commonly applied criteria [16]. Because the path analysis was a secondary exploratory analysis, no separate a priori sample-size calculation was performed specifically for the indirect association. Accordingly, interpretation of the model focused on standardized path coefficients, explained variance (R^2), and the bias-corrected bootstrap confidence interval for the indirect association rather than retrospective post hoc power estimates. Given the cross-sectional design and concurrent measurement of HHBS and HHPI, the path model was interpreted as representing statistical associations within the specified model and not as evidence of temporal or causal mediation

Results

Of the 568 eligible students invited to participate, 432 completed the questionnaire and were included in the analysis, corresponding to a response rate of 76.1%. No initiated questionnaires were incomplete or excluded. The mean age was 20.91±2.18 years (range: 18-39). Females comprised 72.2% of the sample. More than half of the participants (54.2%) reported that income was lower than expenses, and 28.9% reported previous formal hand hygiene training. The most frequently reported perceived reason for poor hand hygiene compliance was limited access

to sinks or antiseptic products (46.1%), followed by lack of belief in the importance of hand hygiene (20.1%) (Table 1).

Table 1. Descriptive characteristics of the participants (N=432)

Variable	Category	n	%
Gender	**Female**	312	72.2
	Male	120	27.8
Economic status	**Income < expenses**	234	54.2
	Income = expenses	174	40.3
	Income > expenses	24	5.5
Field of study	**Nutrition and Dietetics**	120	27.8
	Nursing	120	27.8
	First Aid and Emergency Care	88	20.4
	Elderly Care	104	24.1
Year of study	**1st year**	169	39.1
	2nd year	150	34.7
	3rd year	77	17.8
	4th year	36	8.3
Place of residence	**City**	194	44.9
	Town	153	35.4
	Village	85	19.7
Prior hand hygiene training	**Yes**	125	28.9
	No	307	71.1
Perceived reason for poor compliance	**Limited access to sinks/antiseptics**	199	46.1
	Lack of belief in hand hygiene	87	20.1
	Time constraints	62	14.4
	Skin irritation	54	12.5
	Unpleasant odor	30	6.9
Age (years)	**Mean±SD**	20.91±2.18	
	Min-max	18-39	

The mean HHBS score was 80.23±13.64, and the mean HHPI score was 63.46±9.31 (Table 2).

Table 2. HHBS and HHPI scores

Variable	Mean±SD	Min-max
HHBS	80.23±13.64	22-110
HHPI	63.46±9.31	14-70

Notes: HHBS – Hand Hygiene Belief Scale; HHPI – Hand Hygiene Practice Inventory; SD – standard deviation.

The female participants had higher HHBS scores than the male participants (t(430)=-2.08, p=0.038, d=0.22) and higher HHPI scores (t(430)=-3.26, p=0.001, d=0.35); both differences were small in magnitude. HHPI scores differed significantly across academic years (F(3,428)=5.51, p=0.001, η^2=0.037), representing a small effect. Tukey post-hoc comparisons indicated that second- and fourth-year students had higher HHPI scores than first-year students. Students reporting previous hand hygiene training had higher HHBS scores than those without previous training (t(430)=2.96, p=0.003, d=0.31), corresponding to a small effect, whereas HHPI scores did not differ significantly according to training status (t(430)=-1.03, p=0.304, d=0.10). No statistically significant differences were observed for economic status, field of study, place of residence, or perceived reason for poor hand hygiene compliance (Table 3).

Table 3. Distribution of HHBS and HHPI scores by participant characteristics (N=432)

Variable	Group	n	HHBS mean±SD	HHPI mean±SD	Test results	Effect size
Gender	**Male**	120	78.03±16.09	61.13±11.68	HHBS: t(430)=-2.08, p=0.038; HHPI: t(430)=-3.26, p=0.001	HHBS: d=-0.22; HHPI: d=-0.35
	Female	312	81.08±12.50	64.36±8.07		
Economic status	**Income < expenses**	234	80.61±13.04	63.22±9.41	HHBS: F(2,429)=0.84, p=0.432; HHPI: F(2,429)=0.56, p=0.574	HHBS: η^2=0.004; HHPI: η^2=0.003
	Income = expenses	174	79.37±14.95	63.09±9.62		
	Income > expenses	24	82.75±8.43	65.25±9.45		
Field of study	**Nutrition and Dietetics**	120	79.80±14.45	64.65±8.93	HHBS: F(3,428)=0.17, p=0.917; HHPI: F(3,428)=1.34, p=0.261	HHBS: η^2=0.001; HHPI: η^2=0.009
	Nursing	120	80.32±14.03	62.25±9.89		
	First Aid and Emergency Care	88	81.08±12.51	63.62±8.78		
	Elderly Care	104	79.92±13.30	63.37±9.44		
Year of study	**1st year**	169	79.34±15.29	61.23±11.06	HHBS: F(3,428)=0.61, p=0.609; HHPI: F(3,428)=5.51, p=0.001; Post-hoc HHPI: 2nd > 1st; 4th > 1st	HHBS: η^2=0.004; HHPI: η^2=0.037
	2nd year	150	80.21±14.05	64.96±8.03		
	3rd year	77	81.48±9.25	63.27±8.29		
	4th year	36	81.83±11.60	66.16±7.00		
Place of residence	**City**	194	79.93±14.10	63.25±9.46	HHBS: F(2,429)=0.20, p=0.819; HHPI: F(2,429)=0.37, p=0.691	HHBS: η^2=0.001; HHPI: η^2=0.002
	Town	153	80.16±14.11	63.98±9.45		
	Village	85	81.06±11.81	63.02±9.52		
Prior hand hygiene training	**Yes**	125	83.82±13.46	64.15±8.35	HHBS: t(430)=2.96, p=0.003; HHPI: t(430)=-1.03, p=0.304	HHBS: d=0.31; HHPI: d=0.10
	No	307	79.56±13.78	63.18±9.68		

Perceived reason for poor compliance	**Skin irritation**	54	82.29±11.91	62.20±9.26	HHBS: $F(4,427)=0.69$, $p=0.599$; HHPI: $F(4,427)=0.82$, $p=0.513$	HHBS: $\eta^2=0.006$; HHPI: $\eta^2=0.008$
	Unpleasant odor	30	81.29±13.90	64.83±7.45		
	Lack of belief in hand hygiene	87	80.73±15.22	63.27±9.80		
	Limited access to sinks/antiseptics	199	80.46±11.45	63.83±9.27		
	Time constraints	62	77.30±11.01	62.73±11.06		

Notes: HHBS = Hand Hygiene Belief Scale; HHPI = Hand Hygiene Practice Inventory; SD = standard deviation. Effect sizes are reported as Cohen's *d* for two-group comparisons and η^2 for one-way ANOVA comparisons. For Cohen's *d*, the sign reflects the order of the groups presented in the table; interpretation should primarily consider the magnitude of the effect.

HHBS and HHPI scores were positively correlated (Spearman's r=0.275, $p<0.001$), indicating a weak positive association between stronger beliefs and more frequent self-reported practice (Table 4).

Table 4. Correlation between hand hygiene beliefs and self-reported practices (N=432)

Variable	HHBS	HHPI
HHBS	1.000	0.275*
HHPI	0.275*	1.000

Notes: * Spearman's correlation, $p<0.001$. HHBS – Hand Hygiene Belief Scale; HHPI – Hand Hygiene Practice Inventory.

The exploratory observed-variable path model showed acceptable fit ($\chi^2/df=2.11$, RMSEA=0.059, CFI=0.937, TLI=0.915, SRMR=0.041). Prior hand hygiene training was positively associated with HHBS (β=0.21, $p<0.01$), and HHBS was positively associated with HHPI (β=0.28, $p<0.001$). The direct association between prior training and HHPI was not statistically significant (β=0.07, $p=0.15$). However, the bootstrapped statistical indirect association between prior training and HHPI through HHBS was significant (β=0.06, 95% CI: 0.02800.099, $p<0.01$). Gender was associated with HHBS (β=0.13, $p<0.05$), and academic year was associated with HHPI (β=0.16, $p<0.05$). The model explained 13% of the variance in HHBS and 17% of the variance in HHPI. Given the cross-sectional design, these paths represent statistical associations within the specified model and should not be interpreted as evidence of temporal or causal relationships (Figure 1).

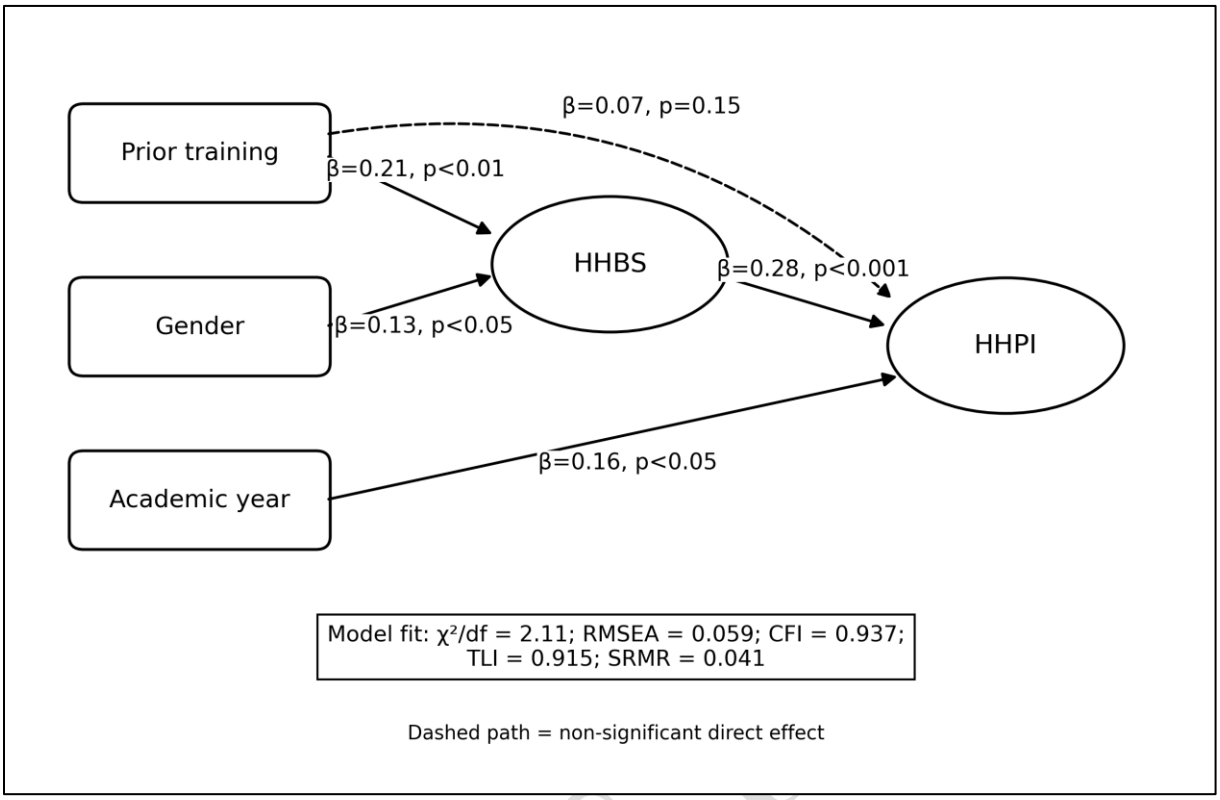

Figure 1. Exploratory observed-variable path model showing statistical associations among previous hand hygiene training, gender, academic year, hand hygiene beliefs (HHBS), and self-reported hand hygiene practices (HHPI)

Notes: Values are standardized path coefficients (β); the dashed path indicates a non-significant association. The model represents cross-sectional statistical associations and does not establish temporal or causal mediation.

Discussion

The principal finding of this study was a weak positive association between stronger hand hygiene beliefs and more frequent self-reported hand hygiene practice. In the exploratory path model, previous hand hygiene training was associated with stronger beliefs, and a small statistical indirect association between previous training and self-reported practice through HHBS was observed. In contrast, the direct association between previous training and HHPI was not statistically significant. Because HHBS and HHPI were measured concurrently within a cross-sectional design, these findings cannot establish that previous training changed students' beliefs or that changes in beliefs subsequently influenced their hand hygiene practices. The indirect

association should therefore be interpreted as a statistical feature of the specified model rather than evidence of a temporal or causal mediating mechanism.

The magnitude of these associations should also be considered when interpreting their practical significance. The correlation between HHBS and HHPI was weak (r=0.275), the standardized indirect association was small (β=0.06), and the model explained 17% of the variance in HHPI. Thus, although beliefs were statistically associated with self-reported practice, they accounted for only a limited proportion of between-student variability. Hand hygiene practice is likely to reflect additional educational, behavioral, and contextual factors that were not captured by the present model. Accordingly, the findings should not be interpreted as indicating that strengthening beliefs alone would necessarily produce substantial changes in actual hand hygiene behavior. Nevertheless, the observed pattern is compatible with theoretical frameworks in which beliefs and attitudes are associated with health-related behavior [11,12] and provides a hypothesis that could be tested prospectively in longitudinal or intervention studies.

Female students reported higher HHBS and HHPI scores than male students. This finding is consistent with the recent global review of health professions students, which noted better attitudes and self-reported practices among female and nursing students [1]. A large Turkish student sample also reported demographic variation in hand hygiene beliefs and practices [2], and a national Italian survey found higher infection-prevention knowledge and self-reported compliance among female respondents [7]. The magnitude of the differences in the present study was modest, so gender should not be interpreted as a fixed determinant. Rather, the result may help identify groups in which targeted reinforcement and skills-based feedback are warranted.

Prior hand hygiene training was associated with higher HHBS scores but not with a direct difference in HHPI scores. Because previous training was assessed only as binary self-reported exposure, and its timing, content, duration, and format were not recorded, the present findings cannot determine which characteristics of educational exposure, if any, were associated with stronger beliefs. Studies using the HHBS/HHPI framework in healthcare personnel have similarly reported associations between education, health beliefs, and hand hygiene behavior [17-19]. Intervention studies provide additional evidence that structured education, practical instruction, and feedback can improve hand hygiene-related outcomes [20-24]. However, these intervention findings should be regarded as complementary evidence from previous research rather than effects demonstrated by the present cross-sectional study.

Academic year was associated with HHPI but not HHBS: second- and fourth-year students reported higher practice scores than first-year students. Recent comparative data showing higher hand hygiene knowledge among final-semester than first-semester nursing students provide a plausible parallel [3]. Progression through training may increase contact with clinical routines, repeated skill assessment, and exposure to role models. Nevertheless, the non-linear pattern in the present data, with no clear stepwise increase across every year, suggests that academic seniority itself should not be treated as a proxy for competence. Curricular content, placement intensity, instructor behavior, and opportunities for supervised practice may be more relevant mechanisms.

The most frequently reported perceived reason for poor hand hygiene compliance was limited access to sinks or antiseptic products. This finding reflects the participants' perceptions and should not be interpreted as evidence that hand hygiene infrastructure or product availability was objectively inadequate at the study institution, as actual resource availability was not assessed. Previous studies have identified access to supplies and institutional conditions as factors associated with hand hygiene behavior [9,10]; however, the present study cannot determine whether the reported perception corresponded to objectively measured environmental limitations. Future studies should therefore assess perceived barriers alongside direct measures of hand hygiene infrastructure and resource availability.

The mean HHPI score was relatively close to the upper end of the possible scale range. However, because the HHPI assesses self-reported behavior, these scores should not be interpreted as objectively observed hand hygiene compliance. Self-reported hand hygiene practices may be influenced by recall error, reporting bias, and social desirability, particularly because hand hygiene is a professionally expected behavior among health professions students. The participants may therefore have reported practices that more closely reflected perceived expectations than their actual behavior in clinical or educational settings. Previous evidence has also demonstrated limited agreement between self-reported and directly observed hand hygiene behavior [25]. Accordingly, the present findings should be interpreted as perceptions of habitual hand hygiene practice rather than objective adherence to hand hygiene recommendations. Future studies should combine validated self-report instruments with structured or covert observation or other objective measures of hand hygiene performance.

This study has several limitations. First, it was conducted at a single university, and participation was voluntary, which may limit the representativeness and external generalizability of the findings. Although all 568 eligible students were invited, and the response rate was 76.1%, self-selection and non-response bias cannot be completely excluded, as students who chose to participate may have differed systematically from those who did not respond. Recruitment through institutional e-mail and course-specific WhatsApp groups may also have favored participation among students who were more engaged with the topic or more responsive to online communication. The single-institution design also prevented evaluation of potential cross-institutional differences in curricula, clinical exposure, educational resources, and hand hygiene training practices. Second, the cross-sectional design and concurrent measurement of HHBS and HHPI preclude conclusions regarding temporal ordering or causal mediation. Because the path analysis was a secondary exploratory analysis, no separate a priori sample-size calculation was performed specifically for the indirect association; therefore, interpretation should emphasize the magnitude and bootstrap confidence interval of the statistical indirect association rather than claims of confirmatory mediation. Third, prior hand hygiene training was assessed as a binary self-reported exposure, and information on its type, timing, duration, frequency, content, and provider was not collected. Consequently, the participants reporting previous training may have received substantially different educational experiences, and the observed association with HHBS should not be interpreted as the effect of a standardized training intervention.

In addition, self-reported HHPI scores may have been influenced by recall, reporting, and social desirability bias. Potential confounders, including clinical-placement intensity, instructor modeling, detailed socioeconomic characteristics, and objectively assessed access to hand hygiene infrastructure, were not fully captured. Finally, the use of total HHBS and HHPI scores as observed variables did not permit item-level latent measurement modeling. Future multicenter longitudinal studies involving universities from different regions and educational settings, incorporating more detailed characterization of educational exposure and objective measures of hand hygiene behavior, are needed to evaluate the temporal ordering and generalizability of these associations.

Conclusions

Among health profession students, stronger hand hygiene beliefs were associated with more frequent self-reported hand hygiene practices. Previous hand hygiene training was associated with stronger beliefs but was not directly associated with self-reported practice. In the exploratory path model, a small statistical indirect association between previous training and self-reported practice through hand hygiene beliefs was observed; however, the cross-sectional design does not establish the temporal sequence or a causal mediating mechanism. Female students reported higher belief and practice scores, and self-reported practice differed across academic years. These findings highlight associations that warrant further investigation using longitudinal, multicenter, and intervention designs incorporating objectively observed hand hygiene behavior.

Disclosures and acknowledgements

The authors thank all the students who participated in the study.

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical approval was obtained from the Ağrı İbrahim Çeçen University Scientific Research and Publication Ethics Committee on September 28th, 2023 (approval/document no. E.80738; ethics decision no. 197). The study was conducted in accordance with the Declaration of Helsinki. The participation was voluntary and anonymous, and all the participants were informed about the purpose of the study, confidentiality, and their right to withdraw. Written/electronic informed consent was obtained before the participation.

The authors declare that no generative artificial intelligence or AI-assisted technologies were used in the preparation, writing, or revision of this manuscript. All the content was conceived, written, and revised by the authors, who take full responsibility for the accuracy and integrity of the final manuscript.

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to ethical and institutional requirements.

References:

1. Shyaka MT, Nzisabira J, Mfura H, Tuli S, Glynn LG. Medical healthcare student's knowledge, attitude, and practices regarding hand hygiene and its relation to patient safety – a global scoping review. Adv Med Educ Pract. 2024; 15: 1041-1055. https://doi.org/10.2147/AMEP.S283642
2. Terzioglu B, Yeniyapi A, Aydin E, Tunc Y, Percin Renders D. Evaluation of beliefs, practices and importance among Health Sciences University students regarding hand hygiene. GMS Hyg Infect Control. 2025; 20: Doc66. https://doi.org/10.3205/dgkh000595
3. Blomgren PO, Swenne CL, Lytsy B, Hjelm K. Hand hygiene knowledge among nurses and nursing students – a descriptive cross-sectional comparative survey using the WHO's Hand Hygiene Knowledge Questionnaire. Infect Prev Pract. 2024; 6(2): 100358. https://doi.org/10.1016/j.infpip.2024.100358
4. Blomgren PO, Hultin L, Westerbergh J, Hjelm K. Attitudes and perceptions toward hand hygiene among nursing students and nurses: a cross-sectional comparative survey. J Adv Nurs. 2026; 82(3): 2245-2256. https://doi.org/10.1111/jan.17076
5. Narula H, Chikara G, Nautiyal S, Singh M, Chandola I. Knowledge, perception, and practices of hand hygiene among medical and paramedical students at a tertiary care institute in Uttarakhand. Cureus. 2024; 16(11): e74812. https://doi.org/10.7759/cureus.74812
6. Venkatasubramanyam NR, Kalyanasundaram AV, Prabhakaran N. Assessment of knowledge, attitude, and practice of hand hygiene among medical students in a tertiary care hospital. Cureus. 2024; 16(8): e66820. https://doi.org/10.7759/cureus.66820
7. Di Gennaro F, Segala FV, Papagni R, De Vita E, Guido G, Frallonardo L, et al. Knowledge, practices, educational needs and hospital engagement in Infection Prevention and Control (IPC) among Italian healthcare workers and students: results from a national multicentre survey. JAC Antimicrob Resist. 2025; 7(3): dlaf081. https://doi.org/10.1093/jacamr/dlaf081
8. Corbo MI, Wachocka M, Pozzi M, Cioce M, Di Donato M, Raponi M, et al. Hand hygiene, knowledge and training motivational drives: findings from a survey in a

university hospital. Front Public Health. 2024; 12: 1421324. https://doi.org/10.3389/fpubh.2024.1421324

9. Harun MGD, Anwar MMU, Sumon SA, Mohona TM, Hassan MZ, Rahman A, et al. Hand hygiene compliance and associated factors among healthcare workers in selected tertiary-care hospitals in Bangladesh. J Hosp Infect. 2023; 139: 220-227. https://doi.org/10.1016/j.jhin.2023.07.012
10. Antinozzi M, Ceparano M, Cammalleri V, Baccolini V, Tufi D, De Giusti M, et al. Compliance with hand-hygiene guidelines among healthcare workers: a cross-sectional study at the Umberto I teaching hospital of Rome, Italy. Ann Ist Super Sanita. 2023; 59(3): 204-212. https://doi.org/10.4415/ANN_23_03_06
11. Ajzen I. The theory of planned behaviour. Organ Behav Hum Decis Process. 1991; 50(2): 179-211. https://doi.org/10.1016/0749-5978(91)90020-T
12. Rosenstock IM. Historical origins of the Health Belief Model. Health Educ Monogr. 1974; 2(4): 328-335. https://doi.org/10.1177/109019817400200403
13. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Methods. 2009; 41: 1149-1160. https://doi.org/10.3758/BRM.41.4.1149
14. van de Mortel TF. Development of a questionnaire to assess health care students' hand hygiene knowledge, beliefs and practices. Aust J Adv Nurs. 2009; 26(3): 9-16. https://doi.org/10.37464/2009.263.1757
15. Karadag M, Pekin Iseri O, Yildirim N, Etikan I. Knowledge, beliefs and practices of nurses and nursing students for hand hygiene. Jundishapur J Health Sci. 2016; 8(4): e36469.
16. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modelling. 1999; 6(1): 1-55. https://doi.org/10.1080/10705519909540118
17. Deniz S. Analysis of hand hygiene belief and practices of health care providers using the hand hygiene belief scale and the hand hygiene practices inventory. Dicle Med J. 2023; 50(3): 335-345. https://doi.org/10.5798/dicletip.1360663

18. Gungordu N, Kurtul S. An evaluation of hand hygiene practices and beliefs of hospital cleaning workers. Karaelmas Journal of Occupational Health and Safety. 2023; 7(3): 139-147. https://doi.org/10.33720/kisgd.1284345
19. Turan F, Eskimez Z. The effect of health belief in health practices: an example of hand hygiene in nurses. Balıkesir Sağlık Bilimleri Dergisi. 2023; 12(1): 1-7. https://doi.org/10.53424/balikesirsbd.1084361
20. Karahan Okuroglu G, Kaynar Simsek A, Pazar N, Ecevit Alpar S. The effect of video-assisted training and visual feedback with UV germ technology on nursing students' hand hygiene beliefs, practices, and compliance: a randomized controlled study. J Nurs Care Qual. 2023; 38(4): 335-340. https://doi.org/10.1097/NCQ.0000000000000710
21. Chen J, Yang L, Mak YW, O'Donoghue M, Shi C, Tsang H, et al. Hand hygiene education components among first-year nursing students: a cluster randomized clinical trial. JAMA Netw Open. 2024; 7(6): e2413835. https://doi.org/10.1001/jamanetworkopen.2024.13835
22. Gammon J, Hunt J, Duffy L, Humphreys I, Hinkin J, Watkins A. Impact of an educational intervention on hand hygiene practice among nursing students, with a focus on hand drying efficacy. J Infect Prev. 2024; 25(1-2): 3-10. https://doi.org/10.1177/17571774231224695
23. Meza Sierra CU, Perez Jaimes GA, Rueda Diaz LJ. Interventions to improve knowledge or compliance to hand hygiene in nursing students: a scoping review. J Infect Prev. 2023; 24(1): 30-44. https://doi.org/10.1177/17571774221127696
24. Gholizad Gougjehyaran H, Motaarefi H, Sakhaei S, Ashrafi M, Zeinalpoor S. The effect of an educational program on hand hygiene compliance among nursing students. BMC Nurs. 2025; 24: 411. https://doi.org/10.1186/s12912-025-03075-z
25. van Dijk MD, Nieboer D, Vos MC, van Beeck EF. Validity of self-reported compliance and behavioural determinants of observed compliance: an application of the COM-B hand hygiene questionnaire in nine Dutch hospitals. J Hosp Infect. 2023; 137: 61-68. https://doi.org/10.1016/j.jhin.2023.04.012