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Patient participation strategies associated with improved patient participation and hand hygiene behaviors in a university hospital

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Abstract

Infection prevention in healthcare settings depends not only on the practices of healthcare workers but also on patients' active participation in safety protocols. While the literature has generally addressed patient participation in care practices, evidence regarding patient participation in infection prevention practices, particularly hand hygiene, remains limited. This study aimed to examine changes in patients' level of participation in patient safety practices and hand hygiene behaviors following the implementation of patient participation strategies for infection prevention. This quasi-experimental and observational study constituted the third and fourth phases of a four-phase doctoral dissertation project for which ethical approval was obtained on 21 May 2021. These two phases were conducted at a university hospital in Turkey between February and April 2025. A total of 58 patients were included. The 696 records represented repeated participant–occasion observations from the same patients and were not independent observations. Data were collected using the Demographic Characteristics Questionnaire, the Patient Participation in Patient Safety Practices Scale (infection subscale), and the Hand Hygiene Observation Form. Data were analyzed using descriptive statistics, the Wilcoxon signed-rank test, Cochran Q test, and McNemar test, with a significance level of $p < .05$. Patient participation scores increased significantly following the intervention (14.83 ± 3.65 vs. 18.12 ± 2.84; $p < .001$), with a large effect size ($r = .79$). After adjustment for multiple comparisons using the Holm method, significant improvements were observed in several hand hygiene steps requiring technical accuracy. For alcohol-based hand rub, improvements in backs of fingers to opposing palms, rotational rubbing of thumbs, and fingertips-to-palm rubbing remained significant across daytime, nighttime, and weekend observations. For soap-and-water hand hygiene, significant improvements were also observed in several technical steps, although not all comparisons remained significant across all observation periods. Structured strategies that promote patient participation can be effective in fostering safe behaviors aimed at preventing infections. Encouraging patients to actively participate in safety practices, such as hand hygiene, can help strengthen patient safety and infection prevention practices in healthcare settings.

Keywords Patient participation · Hand hygiene · Infection prevention · Patient safety · Infection control · Hospitalized patients

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Introduction

Healthcare systems are complex and multidisciplinary, involving collaboration among various professional groups. This complexity increases the likelihood of preventable harm during the delivery of care. Therefore, patient safety is recognized as a fundamental priority of healthcare systems. The World Health Organization defines patient safety as the absence of preventable harm to patients and the reduction of risks associated with healthcare to an acceptable minimum[1]. Current evidence indicates that approximately one in ten patients experiences harm during the delivery of healthcare, with a substantial proportion of these events being preventable[1–3].

Patient participation has emerged as a key approach in reducing preventable harm and improving patient safety. The active involvement of patients and their families in safety-related processes is considered a strategic element in preventing errors and ensuring the sustainability of safe care practices[4,5]. Effective communication, shared decision-making, and patient education are recognized as essential components in strengthening patient participation. In particular, educating patients about infection prevention and safety practices has been shown to enhance risk perception and support the adoption of safer behaviors[6].

The prevention of infections, a key patient safety goal, remains a fundamental priority for healthcare organizations[7]. Healthcare-associated infections constitute a substantial proportion of preventable patient harm. However, these harms can be significantly reduced through effective infection prevention and control programs[8–10]. Among infection prevention practices in healthcare settings, hand hygiene is recognized as one of the most fundamental and effective measures for reducing the transmission of infections. It is emphasized that hand hygiene practices play a critical role in reducing healthcare-associated infections and are an indispensable part of infection prevention programs[11].

However, in recent years, increasing attention has been given to the development and implementation of strategies aimed at promoting patient participation in infection prevention practices. Patient participation in infection control has the potential to support safer care behaviors and enhance overall patient safety[6,12]. However, studies examining the impact of such strategies on patient behaviors remain limited.

Therefore, investigating the effects of strategies that support active patient participation in infection prevention practices on patient behaviors is essential for advancing patient safety initiatives. Accordingly, the aim of this study was to examine the impact of patient participation strategies implemented to prevent infections in a university hospital on patients' levels of participation and hand hygiene behaviors.

Research Question

1. What is the level of patient participation in patient safety practices?
2. What is the impact of the implemented engagement strategies on patients' hand hygiene practices?

Hypotheses

H1 Patient safety interventions implemented for patients increase patient participation in patient safety practices.

H2 Patient participation strategies in patient safety practices increase the accuracy of hand hygiene practices.

Methods

Study design

This study was designed as a quasi-experimental, non-randomized behavioral intervention. Although it included a structured intervention, it did not involve random allocation or controlled clinical comparison and therefore does not meet the criteria for a clinical trial. For this reason, prospective clinical trial registration was not performed.

The study was reported in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statement[13]. The intervention was additionally described in accordance with the Template for Intervention Description and Replication (TIDieR) checklist[14] to ensure transparent and reproducible reporting of the intervention components.

Setting

This study comprised the third and fourth phases of a four-phase doctoral dissertation project. Ethical approval for the project was obtained on 21 May 2021, and the first phase of the dissertation, which involved the development of the patient participation scale, was subsequently conducted. The first phase consisted of the scale-development study for the instrument used in the present research and was conducted between June /2021 and May/2023. The quasi-experimental and observational components reported in this manuscript, corresponding to the third and fourth phases of the dissertation, were conducted at a university hospital in Turkey between February and April 2025.

Participants

The required sample size for the quasi-experimental and observational phases was determined using an a priori power analysis performed with G*Power version 3.1. Assuming a medium effect size (Cohen's $d=0.50$), a significance level of $\alpha=0.05$, and a statistical power of 80% ($1-\beta=0.80$) for the comparison of two dependent means (matched pairs), the minimum required sample size was calculated as 54 participants. To account for potential attrition and missing data, a target sample size of 60 participants was planned. During the predefined data collection period, 58 eligible patients who met the inclusion and exclusion criteria and agreed to participate were enrolled in the study. All 58 enrolled participants completed the study and were included in the analyses. The dataset comprised 696 participant–occasion records obtained through repeated observations of these same patients. During the observational phase, 348 observations of alcohol-based hand rub use were conducted, including 174 pre-intervention observations (daytime, nighttime, and weekend) and 174 post-intervention observations (daytime, nighttime, and weekend). The same observation protocol was repeated for hand hygiene with soap and water, resulting in an additional 348 observations. Overall, the observational phase comprised 696 participant–occasion observations, which represented repeated observations of the same 58 patients rather than independent observations.

Patients were eligible for inclusion if they were aged 18 years or older, were hospitalized in the internal medicine unit during the data collection period, and agreed to participate in the study. Patients with an intravenous line at the wrist that could interfere with the performance of hand hygiene procedures were excluded. No minimum or maximum length of hospital stay was specified as an eligibility criterion.

Intervention

The intervention consisted of two components delivered individually to each patient in a one-to-one format by the same researcher using standardized educational content and a predefined sequence of procedures: (1) hand hygiene with alcohol-based hand rub and (2) hand hygiene with soap and water. Study procedures began on the first day of hospitalization. Pre-intervention data collection also began on that day. During both the pre-intervention and post-intervention observation periods, each patient was observed during three different time periods (daytime, nighttime, and weekends) for both alcohol-based hand rub and soap-and-water hand hygiene.

For the alcohol-based hand rub component, the researcher verbally explained and physically demonstrated each step of the World Health Organization six-step technique to the patient, following a fixed content and sequence, using a visual reminder depicting the steps. The patient was then asked to perform a return demonstration.

For the soap-and-water component, the researcher verbally explained the handwashing steps using the same visual reminder and showed the patient the "Correct Handwashing Technique" (Doğru Yöntemle El Yıkama Deneyi) training video developed by the Turkish Ministry of Health. The patient was then asked to perform handwashing at the sink in the patient's room, and the procedure was observed by the researcher. Each training session lasted approximately 20–30 min. Following completion of the training, small adhesive visual reminders illustrating the correct technique were placed at three locations in the patient's room: on the wall facing the patient's bed, at eye level above the sink, and on the corner of the patient's bedside/meal table. These visual reminders remained in place throughout the post-intervention observation period to reinforce correct hand hygiene practices. The same educational materials, visual reminders, intervention sequence, and observation procedures were used for all participants to ensure intervention fidelity and standardization.

Data collection tools

Data were collected using the Demographic Characteristics Questionnaire, the Hand Hygiene Observation Form and the Patient Participation in Patient Safety Practices Scale (*Infection* sub-dimension).

Data collection procedure

Demographic Characteristics Questionnaire: The questionnaire consisted of five items assessing participants' age, gender, educational level, length of hospital stay, and whether they had received information about hand hygiene during hospitalization.

Observation procedure

Patients' hand hygiene behaviors were assessed through direct observation by the researcher and recorded using a structured Hand Hygiene Observation Form. Each participant completed all study procedures during a single hospitalization. All pre-intervention observations, the intervention, and all post-intervention observations were completed within the same hospitalization episode. The form consisted of 20 items evaluating patients' hand hygiene practices using alcohol-based hand rub and soap and water, including the procedural steps for each method. Each hand hygiene step was assessed as a single item and recorded as correctly performed ("Yes") or not correctly performed ("No") during the observation. The observation form was developed based on the World Health Organization Guidelines on Hand Hygiene in Health Care[15], which provide an internationally accepted reference standard for evaluating the procedural correctness of hand hygiene. Throughout all stages of the study, the target was to evaluate changes in the procedural accuracy of patients' hand hygiene following patient participation intervention. Therefore, procedural correctness was selected as the primary behavioral outcome.

During the observational phase, hand hygiene practices performed using alcohol-based hand rub were evaluated first. Each of the 58 patients was observed during daytime, nighttime, and weekend periods both before and after the intervention. Thus, for alcohol-based hand rub, every patient contributed six repeated participant–occasion records, resulting in 348 records. The same observational procedure was then repeated for hand hygiene with soap and water. Accordingly, each patient again contributed six repeated participant–occasion records, resulting in an additional 348 records. In total, 696 participant–occasion records were obtained. These records represent repeated measurements taken from the same 58 patients, not independent observations.

Observations were conducted systematically according to predefined standard criteria and in a non-interventional manner to avoid influencing patients' behaviors. The researcher recorded whether each step of the hand hygiene technique was performed or not performed using the Hand Hygiene Observation Form, without providing any correction or feedback during the observation. To minimize the potential influence of temporal variability, observations were conducted during daytime, nighttime, and weekend periods. Both pre- and post-intervention

comparisons and the consistency of performance across observation periods were evaluated based on these recordings.

Inter-observer reliability

To ensure that the observational phase of the study could be conducted by a single observer, a pilot observation process was carried out with two independent observers (60 observations) on five patients who were not included in the study sample.

During the pilot phase, hand hygiene practices using alcohol-based hand rub and soap and water were evaluated in both the pre- and post-intervention periods across daytime, nighttime, and weekend time intervals. A total of 60 observations (30 pre-intervention and 30 post-intervention) were conducted independently by the two observers.

Inter-observer agreement was assessed using Cohen's kappa coefficient. For hand hygiene practices performed using alcohol-based hand rub, Cohen's κ was 1.00 across all observation periods, indicating perfect agreement between observers.

For hand hygiene practices performed using soap and water, κ values ranged from 0.55 to 1.00 in the pre-intervention phase, indicating moderate to perfect agreement across items. In the post-intervention phase, κ values were 1.00 for all items, demonstrating perfect agreement.

According to the literature, κ values ≥ 0.60 indicate good agreement, whereas values ≥ 0.80 reflect excellent agreement[16]. Based on the pilot observations, inter-observer agreement was considered sufficient. Therefore, the observational phase of the study was conducted by a single observer, and 696 repeated participant–occasion records were obtained from the same 58 patients; these records were not treated as independent observations.

Patients' participation in patient safety practices was assessed using the infection subscale of the Patient Participation in Patient Safety Practices Scale (PPPSPS)[17]. The PPPSPS used in the present study was developed and psychometrically evaluated during the first (methodological) phase of the same doctoral dissertation project before being applied in the present quasi-experimental study. The validation study was subsequently published in 2025, and the validated version of the infection subscale was used throughout this study. The infection subscale consists of 10 items and is rated on a three-point Likert scale ("Disagree" = 1, "Agree" = 2, and "Strongly Agree" = 3). Scores on the infection subscale range from 10 to 30, with higher scores indicating higher levels of patient participation. The Cronbach's alpha coefficient of the infection subscale was 0.93. The scale was administered before the intervention (pre-test) and after the intervention (post-test). During the pre-intervention period, patients were observed across daytime, nighttime, and weekend hours. Following the implementation of patient participation strategies, including education and visual reminders, the scale was re-administered in the post-intervention phase to assess changes in patient participation levels.

This study was conducted using a single-group pretest–posttest quasi-experimental design. The patient participation strategies, including educational interventions and visual reminders, were applied to all participants. This approach was adopted to ensure that no participants were deprived of the intervention, in line with ethical considerations.

Data analysis

Data were analyzed using descriptive statistics (frequency, percentage, mean, and standard deviation) and inferential statistical tests. The distribution of patient participation scale scores was assessed using skewness and kurtosis. Because post-intervention scores did not meet the assumption of normality, pre- and post-intervention patient participation scores were compared using the Wilcoxon signed-rank test.

For the hand hygiene analyses, the patient was the unit of analysis ($n = 58$). Although 696 participant–occasion records were collected, these records represented repeated measurements from the same patients and were not treated as independent observations. For each hand hygiene step, Cochran's Q test was used to compare the six

related binary measurements obtained from the same 58 patients across the pre-intervention and post-intervention daytime, nighttime, and weekend observation periods. McNemar's test was used to compare paired pre-intervention and post-intervention responses within each observation period, with each comparison based on 58 matched patient pairs. Statistical significance was set at $p < .05$. All analyses were performed using IBM SPSS Statistics, version 26 (IBM Corp., Armonk, NY, USA).

The Holm sequential correction method was used to control the family-wise Type I error rate that may arise from multiple comparisons. For alcohol-based hand rub and soap-and-water practices, the Cochran's Q tests calculated for each hand hygiene step were considered omnibus tests; the Cochran's Q p-values were adjusted using the Holm method, with each hand hygiene method constituting a separate analysis family. For steps whose omnibus test remained significant after the Holm adjustment, pre–post McNemar comparisons for the daytime, nighttime, and weekend periods were considered follow-up analyses. These follow-up comparisons were additionally adjusted using the Holm method within analysis families consisting of 12 comparisons for alcohol-based hand rub practices and 21 comparisons for soap-and-water practices. The original raw p-values were retained in the tables, and Holm-adjusted p-values were also presented separately. For the Wilcoxon signed-rank test, the effect size was calculated using the formula $r = |Z|/\sqrt{N}$; values of approximately 0.10, 0.30, and 0.50 were considered small, medium, and large effects, respectively[18].

Ethical considerations

Ethical approval for this study was initially obtained from the Dokuz Eylul University Non-Interventional Research Ethics Committee (decision date: 21 May 2021, decision no: 2021/15–17). Due to delays in the earlier phases of the dissertation project resulting from the COVID-19 pandemic, this approval was renewed by the same committee prior to the quasi-experimental and observational phase reported in this manuscript (renewal decision date: 9 April 2025, decision no: 2025/12-04). In addition, institutional permissions were obtained from Ege University Hospital, where the third and fourth stages of the thesis were conducted (Date: 28 February 2024). Written informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Participant characteristics

A total of 58 patients were included in the study. The mean age of the participants was 55.00 ± 14.44 years, and the mean length of hospital stay was 7.66 ± 10.34 days. Of the participants, 58.6% were female, and the vast majority (96.6%) had not received any education on hand hygiene during their hospitalization.

Patient participation outcomes

The comparison of patient participation scores (infection sub-dimension) before and after the intervention is presented in Table 1. The mean pre-test score for the infection sub-dimension of the Patient Participation in Patient

Table 1 Comparison of patient participation scores (infection sub-dimension) before and after the intervention.

Variable	*n*	Pre-test (mean ± SD)	Post-test mean ± SD	*p*-value	Effect size
Infection sub-dimension	58	14.83 ± 3.65	18.12 ± 2.84	< 0.001	$r = .79$

Note: P values were calculated using the Wilcoxon signed-rank test. Statistical significance was set at $p < .05$. In the revised inferential evaluation, the effect size appropriate for the Wilcoxon signed-rank test was calculated using the formula $r = |Z|/\sqrt{N}$; for $Z = 6.021$ and $N = 58$, $r = .79$.

Safety Practices Scale was 14.83 ± 3.65, whereas the mean post-test score was 18.12 ± 2.84. Patient participation scores increased significantly following the intervention ($p < .001$). For the Wilcoxon signed-rank test, the effect size calculated using Z = 6.021 and $N = 58$ was $r = .79$, indicating a large effect (Table 1). These findings support the first study hypothesis that patient participation scores would be higher following the intervention.

Hand hygiene outcomes

Hand hygiene practices using alcohol-based hand rub

Changes in alcohol-based hand hygiene practices across different observation periods are presented in Table 2. Following the intervention, significant improvements were observed in several alcohol-based hand hygiene steps. Specifically, significant improvements were found in palms with interlaced fingers, backs of fingers to opposing palms, rotational rubbing of thumbs and fingertips-to-palm rubbing compared with pre-intervention observations (all $p < .05$).

In contrast, no statistically significant differences were observed between pre- and post-intervention for the following hand hygiene steps: *apply hand rub*, *palm-to-palm rubbing*, *backs of hands with interlaced fingers*, *and waiting for hands to dry* (all $p > .05$) (Table 2).

Following the Holm adjustment, the Cochran's Q omnibus results were p_Holm = 0.005 for *palms with interlaced fingers* and p_Holm < 0.001 for *backs of fingers to opposing palms*, *rotational rubbing of thumbs*, and *fingertips-to-palm rubbing.* The Holm-adjusted p-values for *apply hand rub*, *palm-to-palm rubbing*, *backs of hands with interlaced fingers*, and *waiting for hands to dry* were 1.000, 1.000, 1.000, and 0.688 respectively.

Improvements in alcohol-based hand hygiene practices across different time periods are presented in Table 3. McNemar follow-up analyses demonstrated post-intervention improvements in several alcohol-based hand hygiene steps, although not all comparisons remained statistically significant across all observation periods after the Holm adjustment (Table 3). In the Holm-adjusted McNemar follow-up results, the daytime, nighttime, and weekend p_Holm values for *palms with interlaced fingers* were 0.211, 0.211, and 0.211, respectively. For *backs of fingers to opposing palms*, *rotational rubbing of thumbs*, and *fingertips-to-palm rubbing*, p_Holm < 0.001 for all daytime, nighttime, and weekend comparisons.

Table 2 Changes in alcohol-based hand rub hand hygiene across six repeated observation periods among 58 patients.

Hand hygiene steps	Day pre (%)	Day post (%)	Night pre (%)	Night post (%)	Weekend pre (%)	Weekend post (%)	*p*-value	Holm-adjusted *p*
Apply hand rub	100.0	98.3	100.0	98.3	100.0	98.3	0.416	1.000
Palm-to-palm rubbing	98.3	98.3	100.0	98.3	100.0	98.3	0.722	1.000
Backs of hands with interlaced fingers	96.6	98.3	98.3	98.3	98.3	98.3	0.955	1.000
Palms with interlaced fingers	87.9	98.3	87.9	98.3	89.7	98.3	<0.001	0.005
Backs of fingers to opposing palms	27.6	89.7	29.3	94.8	29.3	94.8	<0.001	<0.001
Rotational rubbing of thumbs	39.7	89.7	43.1	91.4	41.4	91.4	<0.001	<0.001
Fingertips-to-palm rubbing	29.3	93.1	32.8	91.4	29.3	89.7	<0.001	<0.001
Waiting for hands to dry	91.4	94.8	91.4	96.6	91.4	96.6	0.172	0.688

Note: Values are presented as percentages based on the 58 patients evaluated at each observation period. The 174 records in each study phase were obtained from three repeated observation periods among the same 58 patients (58 patients × 3 observation periods) and did not represent independent observations. Cochran's Q test was performed using the six related binary measurements obtained from the same 58 patients. Statistical significance was set at $p < .05$. The original raw p-values were retained. The Cochran's Q tests for the alcohol-based hand rub steps were adjusted using the Holm method as a single omnibus analysis family, and the adjusted p-values were added as an additional column.

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Table 3 Improvements in alcohol-based hand hygiene practices by time period after the intervention.

Hand hygiene step	Daytime				Nighttime				Weekend			
	No → Yes *n* (%)	Yes → No *n* (%)	*p*-value	Holm-adjusted *p*	No → Yes *n* (%)	Yes → No *n* (%)	*p*-value	Holm-adjusted *p*	No → Yes *n* (%)	Yes → No *n* (%)	*p*-value	Holm-adjusted *p*
Apply hand rub	0 (0.0)	1 (1.7)	1.000	–	0 (0.0)	1 (1.7)	1.000	–	0 (0.0)	1 (1.7)	1.000	–
Palm-to-palm rubbing	1 (1.7)	1 (1.7)	1.000	–	0 (0.0)	1 (1.7)	1.000	–	0 (0.0)	1 (1.7)	1.000	–
Backs of hands with interlaced fingers	2 (3.4)	1 (1.7)	1.000	–	1 (1.7)	1 (1.7)	1.000	–	1 (1.7)	1 (1.7)	1.000	–
Palms with interlaced fingers	7 (12.1)	1 (1.7)	0.070	0.211	7 (12.1)	1 (1.7)	0.070	0.211	6 (10.3)	1 (1.7)	0.125	0.211
Backs of fingers to opposing palms	36 (62.1)	0 (0.0)	<0.001	<0.001	38 (65.5)	0 (0.0)	<0.001	<0.001	38 (65.5)	0 (0.0)	<0.001	<0.001
Rotational rubbing of thumbs	30 (51.7)	1 (1.7)	<0.001	<0.001	29 (50.0)	1 (1.7)	<0.001	<0.001	30 (51.7)	1 (1.7)	<0.001	<0.001
Fingertips-to-palm rubbing	37 (63.8)	0 (0.0)	<0.001	<0.001	34 (58.6)	0 (0.0)	<0.001	<0.001	35 (60.3)	0 (0.0)	<0.001	<0.001
Waiting for hands to dry	3 (5.2)	1 (1.7)	0.625	–	4 (6.9)	1 (1.7)	0.375	–	4 (6.9)	1 (1.7)	0.375	–

Note: Values represent the number and percentage of patients who did not perform the relevant hand hygiene step before the intervention but performed it after the intervention. McNemar's test was performed separately for the daytime, nighttime, and weekend observation periods using the paired pre-intervention and post-intervention responses of the same 58 patients. Therefore, each comparison was based on 58 matched patient pairs rather than independent observation records. Statistical significance was set at $p < .05$. The original McNemar p-values were retained. A total of 12 follow-up comparisons corresponding to the four steps for which the Holm-adjusted omnibus Cochran's Q result was significant were adjusted using the Holm method within a single analysis family. For steps for which the omnibus test was not significant, the adjusted follow-up p-value was not reported (–). The value presented next to the original p-value is the Holm-adjusted p-value.

Hand hygiene practices using soap and water

Changes in hand hygiene practices using soap and water across different time periods are presented in Table 4. Following the intervention, improvements were observed in the majority of hand hygiene practices performed using soap and water. Statistically significant increases in compliance rates were found for *removing accessories*, w*et hands with water*, *rotational rubbing of thumbs*, *wrist rubbing*, and *using tissue to turn off the faucet* ($p < .05$).

In contrast, no statistically significant differences were observed in steps with already high baseline compliance, including *apply soap and lather hands*, *rinsing hands with water*, and *drying hands* ($p > .05$) (Table 4).

Following the Holm adjustment, the Cochran's Q omnibus results were p_Holm < 0.001 for *removing accessories*, *wet hands with water*, *palms with interlaced fingers*, *rotational rubbing of thumbs*, *fingertips-to-palm rubbing*, *wrist rubbing*, and *using tissue to turn off the faucet.* The p_Holm values for *apply soap and lather hands*, *backs of hands with interlaced fingers*, *rinsing hands with water*, and *drying hands* were 0.213, 0.416, 0.213, and 0.213, respectively. For *palm-to-palm rubbing*, the Cochran's Q statistic was not calculated because all measurements were identical.

Improvements in hand hygiene practices using soap and water across different time periods are presented in Table 5.

McNemar follow-up analyses demonstrated post-intervention improvements in several hand hygiene steps, although not all comparisons remained statistically significant across all observation periods after the Holm adjustment (Table 5). These findings support the second study hypothesis that patients' procedural accuracy in hand hygiene practices would be higher following the intervention.

In the Holm-adjusted McNemar follow-up results, the daytime, nighttime, and weekend p_Holm values were 0.016, 0.009, and 0.027, respectively, for *removing accessories*, 0.027, 0.063, and 0.063 for *wet hands with water*; and 0.027, 0.031, and 0.031 for *palms with interlaced fingers*. For *rotational rubbing of thumbs*, *fingertips-to-palm rubbing*, *wrist rubbing*, and *using tissue to turn off the faucet*, p_Holm < 0.001 for all three observation periods.

Table 4 Changes in soap-and-water hand hygiene across six repeated observation periods among 58 patients.

Steps	Day pre (%)	Day post (%)	Night pre (%)	Night post (%)	Weekend pre (%)	Weekend post (%)	*p*-value	Holm-adjusted *p*
Removing accessories	82.8	100.0	81	100.0	82.8	100.0	<0.01	<0.001
Wet hands with water	84.5	100.0	89.7	100.0	89.7	100.0	<0.01	<0.001
Apply soap and lather hands	94.8	100.0	96.6	100.0	98.3	100.0	0.053	0.213
Palm-to-palm rubbing	100.0	100.0	100.0	100.0	100.0	100.0	–	–
Backs of hands with interlaced	98.3	100.0	98.3	100.0	98.3	100.0	0.416	0.416
Palms with interlaced fingers	84.5	100.0	86.2	100.0	86.2	100.0	<0.001	<0.001
Rotational rubbing of thumbs	36.2	94.8	41.4	94.8	43.1	93.1	<0.001	<0.001
Fingertips-to-palm rubbing	22.4	96.6	29.3	94.8	31.0	94.8	<0.001	<0.001
Wrist rubbing	39.7	91.4	37.9	93.1	37.9	94.8	<0.001	<0.001
Rinsing hands with water	96.6	100.0	100.0	100.0	100.0	100.0	0.075	0.213
Drying hands	94.8	100.0	98.3	100.0	98.3	100.0	0.056	0.213
Using tissue to turn off the faucet	12.1	65.5	13.8	58.6	13.8	62.1	<0.001	<0.001

Note: Values are presented as percentages based on the 58 patients evaluated at each observation period. The 174 records in each study phase were obtained from three repeated observation periods among the same 58 patients (58 patients × 3 observation periods) and did not represent independent observations. Cochran's Q test was performed using the six related binary measurements obtained from the same 58 patients. Statistical significance was set at $p < .05$. The original raw p-values were retained. The Cochran's Q tests for the soap-and-water hand hygiene steps were adjusted using the Holm method as a single omnibus analysis family, and the adjusted p-values were added to the corresponding cells. The value presented next to the original p-value is the Holm-adjusted p-value.

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Table 5 Improvements in hand hygiene practices using soap and water by time period after the intervention.

Hand hygiene step	Daytime				Nighttime				Weekend			
	No→Yes *n* (%)	Yes→No *n* (%)	*p*-value	Holm-adjusted *p*	No→Yes *n* (%)	Yes→No *n* (%)	*p*-value	Holm-adjusted *p*	No→Yes *n* (%)	Yes→No *n* (%)	*p*-value	Holm-adjusted *p*
Removing accessories	10 (17.2)	0 (0.0)	0.002	0.016	11 (19.0)	0 (0.0)	<0.001	0.009	9 (15.5)	0 (0.0)	0.004	0.027
Wet hands with water	9 (15.5)	0 (0.0)	0.004	0.027	6 (10.3)	0 (0.0)	0.031	0.063	6 (10.3)	0 (0.0)	0.031	0.063
Apply soap and lather hands	3 (5.2)	0 (0.0)	0.250	–	2 (3.4)	0 (0.0)	0.500	–	1 (1.7)	0 (0.0)	1.000	–
Palm-to-palm rubbing	0 (0.0)	0 (0.0)	–	–	0 (0.0)	0 (0.0)	–	–	0 (0.0)	0 (0.0)	–	–
Backs of hands with interlaced fingers	1 (1.7)	0 (0.0)	1.000	–	1 (1.7)	0 (0.0)	1.000	–	1 (1.7)	0 (0.0)	1.000	–
Palms with interlaced fingers	9 (15.5)	0 (0.0)	0.004	0.027	8 (13.8)	0 (0.0)	0.008	0.031	8 (13.8)	0 (0.0)	0.008	0.031
Rotational rubbing of thumbs	34 (58.6)	0 (0.0)	<0.001	<0.001	31 (53.4)	0 (0.0)	<0.001	<0.001	29 (50.0)	0 (0.0)	<0.001	<0.001
Fingertips-to-palm rubbing	43 (74.1)	0 (0.0)	<0.001	<0.001	38 (65.5)	0 (0.0)	<0.001	<0.001	37 (63.8)	0 (0.0)	<0.001	<0.001
Wrist rubbing	30 (51.7)	0 (0.0)	<0.001	<0.001	32 (55.2)	0 (0.0)	<0.001	<0.001	33 (56.9)	0 (0.0)	<0.001	<0.001
Rinsing hands with water	2 (3.4)	0 (0.0)	0.500	–	0 (0.0)	0 (0.0)	–	–	0 (0.0)	0 (0.0)	–	–
Drying hands	3 (5.2)	0 (0.0)	0.250	–	1 (1.7)	0 (0.0)	1.000	–	1 (1.7)	0 (0.0)	1.000	–
Using tissue to turn off the faucet	31 (53.4)	0 (0.0)	<0.001	<0.001	26 (44.8)	0 (0.0)	<0.001	<0.001	28 (48.3)	0 (0.0)	<0.001	<0.001

Note: Values represent the number and percentage of patients who did not perform the relevant hand hygiene step before the intervention but performed it after the intervention. McNemar's test was performed separately for the daytime, nighttime, and weekend observation periods using the paired pre-intervention and post-intervention responses of the same 58 patients. Therefore, each comparison was based on 58 matched patient pairs rather than independent observation records. Statistical significance was set at $p < .05$. The original McNemar p-values were retained. A total of 21 follow-up comparisons corresponding to the seven steps for which the Holm-adjusted omnibus Cochran's Q result was significant were adjusted using the Holm method within a single analysis family. For steps for which the omnibus test was not significant, the adjusted follow-up p-value was not reported (–). The value presented next to the original p-value is the Holm-adjusted p-value.

Discussion

The results of this study suggest that the implementation of patient participation strategies was associated with higher levels of patient participation in infection prevention processes and greater accuracy of hand hygiene practices following the intervention. The observed increase in patient participation scores following the intervention, together with the large effect size ($r = .79$), suggests that education, visual reminders, and guidance may represent promising strategies for supporting behavioral change. The observed improvement corresponded to an increase of 3.29 points on the infection subscale, which has a possible score range of 10 to 30. Although a minimally important clinical difference has not yet been established for the Patient Participation in Patient Safety Practices Scale, the combination of this absolute improvement and the large standardized effect size suggests that the intervention was associated with a substantial improvement in patient participation in infection prevention practices during hospitalization. The fact that nearly all participants (96.6%) had not received hand hygiene education during hospitalization before the intervention may partly explain the magnitude of the observed improvements. Consistent with our findings, previous studies have reported that even brief interventions can enhance patient participation and promote safety-related behaviors[19,20]. These findings support the potential role of patients as active partners in infection prevention and control rather than passive recipients of care.

The findings of this study suggest that improvements following the intervention were more evident in hand hygiene steps requiring greater technical accuracy. The high baseline compliance observed for fundamental hand hygiene steps may explain why no significant changes were observed in these steps following the intervention. In contrast, greater improvements were observed in more technically demanding hand hygiene steps, such as rotational rubbing of the thumbs, fingertips-to-palm rubbing, and rubbing the palms with interlaced fingers. Previous studies have shown that these steps are often neglected by both healthcare workers and patients[8,21,22]. After controlling for multiple comparisons using the Holm method, follow-up McNemar comparisons remained significant across daytime, nighttime, and weekend periods for three of the four alcohol-based hand rub steps with statistically significant omnibus Cochran's Q results, whereas the Holm-adjusted follow-up comparisons for *palms with interlaced fingers* were not significant. For soap-and-water hand hygiene, only the daytime follow-up comparison remained significant for *wet hands with water*, whereas the Holm-adjusted follow-up comparisons remained significant for *removing accessories*, *palms with interlaced fingers*, *rotational rubbing of thumbs*, *fingertips-to-palm rubbing*, *wrist rubbing*, *and using tissue to turn off the faucet.* Overall, after accounting for multiple testing, post-intervention changes were more consistently observed in specific hand hygiene steps requiring greater technical accuracy.

The lack of significant change in certain hand hygiene behaviors may be explained by the habitual and automatic nature of these behaviors, making them less responsive to short-term interventions. Previous studies have reported that behaviors such as "waiting for hands to dry" are more difficult to modify through short-term interventions[23,24]. This finding suggests that one-time interventions may be insufficient to modify such habitual behaviors and highlights the potential value of ongoing supportive strategies.

The improvements observed in both alcohol-based hand rub and soap-and-water hand hygiene practices, particularly in technical steps aligned with World Health Organization hand hygiene standards, suggest that patient participation strategies may represent a promising approach for supporting hand hygiene practices relevant to infection prevention[15].

The lack of significant differences in some hand hygiene steps with high baseline compliance may reflect a ceiling effect. Previous studies evaluating multimodal interventions, including World Health Organization strategies, have reported greater improvements in technical steps that are frequently performed incorrectly or incompletely, whereas the potential for improvement is often limited in steps with high baseline adherence[25–27]. In this context, the magnitude of post-intervention change observed in the present study may have varied according to baseline performance.

A marked improvement was observed in the use of a tissue to turn off the faucet. This behavior is considered an important step in reducing the risk of recontamination after hand hygiene and has been reported as one of the least consistently performed steps in the literature[28]. The marked improvement observed in this step suggests that the intervention may have been associated with greater attention to practices intended to prevent cross-contamination.

Previous studies have similarly highlighted the potential role of patient participation in supporting hand hygiene practices and infection prevention behaviors[19,29]. The present findings are consistent with growing evidence that patients may be supported to participate as active partners in infection prevention when provided with appropriate education and support[5,15,20,29]. Educational interventions combined with visual reminders may therefore represent a promising strategy for supporting patient participation and hand hygiene practices.

The findings of this study suggest that improvements in hand hygiene behaviors and patient participation in infection prevention practices were observed following the implementation of patient participation strategies. However, given the quasi-experimental design and the absence of a control group, these results should be interpreted with caution. The observed improvements may be influenced by contextual or temporal factors, and causal relationships cannot be definitively established. Such alternative explanations may include concurrent changes in hospital policy, staff behavior, seasonal influences, and regression to the mean. Nevertheless, the consistent improvements across different observation periods indicate that structured patient participation strategies may contribute to enhancing patient safety behaviors in clinical settings.

This study has several limitations that should be considered when interpreting the findings. First, the absence of a control group, together with the quasi-experimental design, limits the ability to establish causal relationships between the intervention and the observed outcomes.

An important limitation concerns the potential for detection bias related to the observation process. Although inter-observer agreement was established during the pilot phase (five patients, 60 observations), all 696 observations in the main study sample were subsequently conducted by a single, non-blinded observer who also delivered the intervention. Because this observer was aware of whether a given observation occurred before or after the intervention, the possibility of detection bias—a tendency to score post-intervention performance more favorably—cannot be excluded. This potential bias should be considered when interpreting the observed pre–post differences. Future studies should address this limitation through the use of blinded, independent assessors before and after the intervention.

In addition, although direct observation enhanced the reliability of the behavioral assessments, it may also have introduced an observer effect (the Hawthorne effect). This represents a limitation distinct from detection bias, as participants' awareness of being observed may itself have influenced their hand hygiene behaviors.

The use of a convenience sampling method and the single-center design may limit the generalizability of the findings. In addition, the use of patient self-reported data for certain variables may have introduced response bias. The study focused on the procedural accuracy of hand hygiene. Therefore, the fact that other determinants of infection prevention, such as the timing or frequency of hand hygiene practices, were not evaluated can be considered a limitation. Finally, the study did not include clinical outcome measures, such as healthcare-associated infection rates, which limits the ability to evaluate whether the observed behavioral improvements were associated with corresponding clinical outcomes.

Despite these limitations, the use of direct and structured observation represents an important strength of this study by providing a more objective assessment of patient hand hygiene behaviors. Future controlled studies with longer follow-up periods should determine whether the observed behavioral improvements are sustained over time and are associated with clinical outcomes, including healthcare-associated infection rates.

In conclusion, patient participation strategies were associated with significant improvements, particularly in hand hygiene steps requiring greater technical accuracy. These findings suggest that structured patient participation strategies may represent a promising complementary approach for supporting infection prevention practices. Given the limited evidence on patient-centered infection prevention approaches, this study contributes to the growing body of evidence on the potential role of patient participation in infection prevention.

Conclusion

The findings of this study suggest that patient participation strategies, including education and visual reminders, were associated with improvements in hand hygiene behaviors and patient participation in infection prevention practices. The most pronounced improvements were observed in technically demanding hand hygiene practices following the intervention.

These findings reinforce the potential role of patient-centered approaches in supporting patients' active involvement in infection prevention practices. Furthermore, similar patterns of improvement were observed in both alcohol-based hand rub and soap-and-water hand hygiene practices, suggesting that patient participation strategies may be applicable across different hand hygiene methods.

Given the critical role of hand hygiene in preventing healthcare-associated infections, integrating patient participation into infection prevention and control programs may represent a promising complementary approach. However, further well-designed controlled studies are needed to evaluate the long-term sustainability of the observed behavioral improvements and to determine whether they are associated with clinical outcomes, including healthcare-associated infection rates.

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Data availability The datasets generated and analyzed during this study are not publicly available due to ethical and privacy restrictions involving patient data, but are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare no competing interests.

Ethics approval and consent to participate Ethical approval for this study was initially obtained from the Dokuz Eylul University Non-Interventional Research Ethics Committee (decision date: 21 May 2021, decision no: 2021/15–17) and was renewed by the same committee prior to the quasi-experimental and observational phases of the study (renewal decision date: 9 April 2025, decision no: 2025/12 − 04). Institutional permissions were obtained from Ege University Hospital. Written informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication All authors have read and approved the final manuscript and consent to its publication.

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References

1. World Health Organization. *Patient safety: fact sheet* (World Health Organization, 2023). https://www.who.int/news-room/fact-sheets/detail/patient-safety. Accessed February, 2026.
2. Hibbert, P. D. et al. Improving health system responses when patients are harmed: a protocol for a multistage mixed-methods study. *BMJ Open.***14**, e085854. https://doi.org/10.1136/bmjopen-2024-085854 (2024).
3. World Health Organization. *Global patient safety action plan* (World Health Organization, 2025). https://www.who.int/teams/integrated-health-services/patient-safety/policy/global-patient-safety-action-plan. Accessed February, 2026.
4. Lawton, R. et al. Can patient involvement improve patient safety? *BMJ Qual. Saf.***26** (8), 622–631. https://doi.org/10.1136/bmjqs-2016-005570 (2017).
5. Fernandes Agreli, H. et al. Patient involvement in infection prevention and control: a scoping review. *BMJ Open.***9** (3), e025824. https://doi.org/10.1136/bmjopen-2018-025824 (2019).
6. Hammoud, S., Amer, F., Lohner, S. & Kocsis, B. Patient education on infection control: a systematic review. *Am. J. Infect. Control*. **48** (12), 1506–1515. https://doi.org/10.1016/j.ajic.2020.05.039 (2020).
7. Joint Commission International. International patient safety goals. Accessed April 2, 2026. https://www.jointcommissioninternational.org/standards/international-patient-safety-goals/ (2026).
8. World Health Organization. *WHO launches first global report on infection prevention and control* (World Health Organization, 2022). February, 2026. https://www.who.int/news/item/06-05-2022-who-launches-first-ever-global-report-on-infection-prevention-and-control.
9. Razzaque, M. S. Healthcare-associated infections in the context of the pandemic. *Front. Health Serv.***3**, 112345. https://doi.org/10.3389/frhs.2023.1288033 (2023).
10. European Centre for Disease Prevention and Control. *Healthcare-associated infections in the EU/EEA* (ECDC, 2024). https://www.ecdc.europa.eu/en/news-events/each-year-43-million-patients-hospitals-eueea-are-affected-healthcare-associated-infections. Accessed September 10, 2025.
11. Lotfinejad, N. et al. Hand hygiene in health care: 20 years of advances. *Lancet Infect. Dis.***21** (8), e209–e221. https://doi.org/10.1016/S1473-3099(21)00383-2 (2021).
12. Mbamalu, O. et al. Patient understanding of and participation in infection-related care across surgical pathways: a scoping review. *Int. J. Infect. Dis.***110**, 123–134. https://doi.org/10.1016/j.ijid.2021.07.039 (2021).
13. Des Jarlais, D. C., Lyles, C., Crepaz, N. & TREND Group. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. *Am. J. Public. Health*. **94** (3), 361–366. https://doi.org/10.2105/ajph.94.3.361 (2004).
14. Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., & Michie, S. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ***348**. https://doi.org/10.1136/bmj.g1687 (2014).
15. World Health Organization. *WHO guidelines on hand hygiene in health care* (WHO, 2009). https://www.who.int/publications/i/item/9789241597906. Accessed February, 2026.
16. Landis, J. R. & Koch, G. G. The measurement of observer agreement. *Biometrics***33** (1), 159–174. https://doi.org/10.2307/2529310 (1977).
17. Dursun Engin, M. & Seren Intepeler, S. Patient participation in patient safety practices scale: development and psychometric evaluation. *Healthcare***13** (12), 1387. https://doi.org/10.3390/healthcare13121387 (2025).
18. Holm, S. A simple sequentially rejective multiple test procedure. *Scand. J. Stat.***6** (2), 65–70 (1979).
19. Aho-Glele, U., Pomey, M. P., Gomes de Sousa, M. R. & Bouabida, K. An evidence-based tool (PE for PS) for healthcare managers to assess patient engagement for patient safety in healthcare organizations. *Patient Exp. J.***8** (1), 45–58. https://doi.org/10.35680/2372-0247.145 (2021).
20. Clavel, N. C. et al. Patient and family engagement in infection prevention in the context of the COVID-19 pandemic: defining a consensus framework using the Q methodology – NOSO-COVID study protocol. *BMJ Open.***12**, e056172. https://doi.org/10.1136/bmjopen-2021-056172 (2022).
21. Kingston, L., O'connell, N. H. & Dunne, C. P. Hand hygiene trials since 2010. *J. Hosp. Infect.***92** (4), 309–320. https://doi.org/10.1016/j.jhin.2015.11.012 (2016).
22. Sunkesula, V. C., Kundrapu, S., Knighton, S., Cadnum, J. L. & Donskey, C. J. A Randomized Trial to Determine the Impact of an Educational Patient Hand-Hygiene Intervention on Contamination of Hospitalized Patient's Hands with Healthcare-Associated Pathogens. *Infect. Control Hosp. Epidemiol.***38** (5), 595–597. https://doi.org/10.1017/ice.2016.323 (2017).
23. Lally, P., Van Jaarsveld, C. H., Potts, H. W. & Wardle, J. How are habits formed: Modelling habit formation in the real world. *Eur. J. Soc. Psychol.***40** (6), 998–1009 (2010).
24. Gardner, B. et al. Developing habit-based health behaviour change interventions: twenty-one questions to guide future research. *Psychol. Health*. **38** (4), 518–540. https://doi.org/10.1080/08870446.2021.2003362 (2023).
25. Phan, H. T. et al. An educational intervention to improve hand hygiene compliance in Vietnam. *BMC Infect. Dis.***18**, 116. https://doi.org/10.1186/s12879-018-3029-5 (2018).

26. Pittet, D. et al. Effectiveness of a hospital-wide programme. *Lancet***356** (9238), 1307–1312. https://doi.org/10.1016/S0140-6736(00)02814-2 (2000).
27. de Kraker, M. E. et al. Implementation of hand hygiene in health-care facilities. *Lancet Infect. Dis.***22** (6), 835–844. https://doi.org/10.1016/S1473-3099(21)00618-6 (2022).
28. Centers for Disease Control and Prevention. *Hand hygiene for patients* (CDC, 2020). https://www.cdc.gov/clean-hands/about/hand-hygiene-for-healthcare.html. Accessed November 28, 2025.
29. Alzyood, M., Jackson, D., Aveyard, H. & Brooke, J. COVID-19 reinforces the importance of handwashing. *J. Clin. Nurs.***29** (15–16), 2760–2761. https://doi.org/10.1111/jocn.15313 (2020).

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