



## Hemşirelerin El Hijyeninin Değerlendirilmesi: Pandemi Öncesi ve Pandemi Sonrası Dönemlere Kapsamlı Bir Analiz

Assessing Nurses Hand Hygiene: A Comprehensive Analysis from Pre-Pandemic to Post-Pandemic Periods

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Geliş Tarihi (Received): 16.08.2024

Kabul Tarihi (Accepted): 10.03.2025

Yayın Tarihi (Published): 18.04.2025

**Abstract:** This longitudinal multicenter study, it was aimed to examine the hand hygiene practices of nurses in pre-pandemic, pandemic and post-pandemic periods. The study was conducted in a private health institution in Turkey (2019-2023). Hand hygiene assessment was done among 2253 nurses using Hand-in-Scan™ (Semmelweis Systems by Hand-in-Scan; Hungary) technology. In the pre-pandemic phase, a sample of 936 evaluation was used as a set baseline mean cleanliness score of 93.32 (establishing a reference point for subsequent evaluations). During the pandemic, there was a significant increase in the evaluation scores, with an average score of 97.94 based on 892 recorded assessments conducted using this system. This increase emphasizes the intensified focus on hygiene protocols during the pandemic, indicative of heightened awareness and adherence to hand hygiene practices. At the post-pandemic phase, with 425 observations, demonstrated a slight decline in the mean cleanliness score to 96.79. Despite this decrease, the overall cleanliness levels remained notably higher than the pre-pandemic baseline. A detailed breakdown of mean cleanliness scores for different hand regions, along with 95% Confidence Intervals, offered nuanced insights into expected cleanliness levels during each period. Statistical analysis revealed highly significant differences in hand hygiene practices between the pre-pandemic period and both the pandemic and post-pandemic periods. Interestingly, no significant difference was found between the post-pandemic and pandemic periods, indicating that the elevated levels of hand hygiene practices observed during the pandemic were maintained even after it ended. The study not only contributes valuable insights into evolving hand hygiene practices but also highlights the lasting impact of increased awareness and adherence introduced during the pandemic. The incorporation of Hand-in-Scan™ technology enriches measurement precision, augmenting overall hand hygiene compliance within healthcare settings. The findings underscore the need for continued emphasis on hand hygiene protocols, emphasizing their enduring impact on healthcare practices beyond the pandemic.

**Keywords:** Hand hygiene, Nurses, Pandemic, Hand-in-Scan™ technology, Post-pandemic, Pre-pandemic

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**Öz:** Bu boyölamsal çok merkezli çalışmada, pandemi öncesi, pandemi ve pandemi sonrası dönemlerde hemşirelerin el hijyeni uygulamalarının incelenmesi amaçlandı. Çalışma Türkiye'de özel bir sağlık kuruluşunda gerçekleştirildi (2019-2023). El hijyeni değerlendirilmesi, Hand-in-Scan™ (Semmelweis Systems by Hand-in-Scan; Macaristan) teknolojisi kullanılarak 2253 hemşire ile yapıldı. Elde edilen bulgulara göre, pandemi öncesi dönemde 936 örnekleme 93,32'lik bir temizlik puanı belirlendi. Ancak, pandemi döneminde kaydedilen örneklerin ortalaması dikkat çekici bir şekilde arttı, 892 kaydedilen örnekleme ortalama 97,94 puan görüldü. Bu artış, pandemi sürecinde hijyen protokollerine odaklanmanın ve el hijyeni uygulamalarına artan farkındalığın bir göstergesidir. Pandemi sonrası dönemde ise, 425 örnekleme birlikte ortalama temizlik puanında 96,79'a kadar hafif bir düşüş gözlemlendi. Farklı el bölgeleri için ortalama temizlik puanlarının ayrıntılı bir dökümü ve %95 Güven Aralıkları, her dönem boyunca beklenen temizlik seviyelerine ilişkin ayrıntılı bilgiler sundu. İstatistiksel analizler, pandemi öncesi dönem ile hem pandemi sonrası hem de pandemi dönemleri arasında oldukça anlamlı farklılıklar olduğunu ortaya koydu. Ancak, pandemi sonrası ve pandemi dönemleri arasında önemli bir fark tespit edilmedi ve pandemi sırasında gözlemlenen yüksek seviyelerle karşılaştırılabilir bir pandemi sonrası el hijyeni uygulamalarının devam ettiği vurgulandı. Bu çalışma, el hijyeni uygulamalarının gelişimine ilişkin değerli bilgiler sunmanın yanı sıra, pandemi sırasında artan farkındalık ve bağlılığın kalıcı etkisinin altını çizmektedir. Hand-in-Scan™ teknolojisinin kullanılması, ölçümlerin hassasiyetini artırarak sağlık hizmeti ortamlarında el hijyeni protokollerine uyumu güçlendirmektedir. Sonuçlar, el hijyeni prosedürlerine ve bunların pandeminin ötesinde sağlık hizmetleri uygulamaları üzerindeki kalıcı etkilerine sürekli dikkat edilmesi gerektiğinin altını çizmektedir.

**Anahtar Kelimeler:** El hijyeni, Hemşireler, Pandemi, Hand-in-Scan™ teknolojisi, Pandemi sonrası, Pandemi öncesi

**Atıf/Cite as:** Aslan SK, Kocagöz AS, Bozkır G, Çakın NŞ. Assessing Nurses Hand Hygiene: A Comprehensive Analysis from Pre-Pandemic to Post-Pandemic Periods. Abant Sağlık Bilimleri ve Teknolojileri Dergisi. 2025;5(1):15-25.

**İntihal-Plagiarizm/Etik-Ethic:** Bu makale, en az iki hakem tarafından incelenmiş ve intihal içermediği, araştırma ve yayın etiğine uyulduğu teyit edilmiştir. / This article has been reviewed by at least two referees and it has been confirmed that it is plagiarism-free and complies with research and publication ethics. <https://dergipark.org.tr/tr/pub/sabited/policy>

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## Introduction

Maintaining effective hand hygiene practices is critical in healthcare settings to prevent the transmission of infectious agents and reduce the risk of healthcare-associated infections (HAIs) (1-4). The significance of hand hygiene in infection control is well-established, emphasizing the need for meticulous practices before and after patient contact, between care activities, and following potential hand contamination events (4-6). The choice of hand antiseptic solutions, their application methods, and stability considerations are critical factors influencing efficacy (7). While soap and water are essential for visibly soiled hands, both options are acceptable for visibly clean hands, alcohol-based hand rubs, following European standards (EN 1499 and EN 1500) and WHO recommendations, are recognized as key measures in preventing HAIs (7-10).

The effectiveness of hand hygiene protocols relies on maintaining correct techniques over time. Long-term programs emphasize sustained improvement through education and training, with monitoring and reporting success integral to quality improvement initiatives (2,9,11). Despite established protocols, achieving and sustaining proper hand hygiene compliance among healthcare workers remains challenging. Continuous re-education and training, often overlooked, lead to poor compliance. Various studies underscore the need for educational interventions and training programs, particularly during the COVID-19 pandemic (9, 12-15).

The COVID-19 pandemic has heightened awareness, with initiatives like the Rapid Hand Hygiene Training Program playing a pivotal role in crisis management, providing swift and effective solutions to uphold hand hygiene standards (15). Various methods and tools, such as direct observation, electronic monitoring systems, surveys, and self-reporting, are employed to measure and monitor hand hygiene compliance in healthcare settings. Combining these methods provides a comprehensive understanding, contributing to sustained improvements in compliance rates and patient safety (16-26). Ensuring nurses' adherence to handwashing protocols is crucial for infection prevention and patient safety (1,25). Hand hygiene remains a cornerstone in global healthcare infection prevention efforts. Enhancing education and fostering behavior change are integral components, further fortified by the continuous monitoring and feedback of hand hygiene performance. Diverse measurement methods, including advanced technologies like Hand-in-Scan™, offer a multifaceted approach to maintaining and improving hand hygiene compliance among healthcare workers (18, 27). These endeavors underscore a commitment to transparency, accountability, and ongoing improvement in hand hygiene practices.

Duong et al's study revealed an alarming statistic that 92,9% of subjects did not adequately cover their hands with alcohol-based hand sanitizer, with fingertips and backs of hands being the most frequently missed areas. To address this issue, the Semmelweis Hand Hygiene System, Hand-in-Scan™ was used, which provides a real-time assessment of subjects' disinfection technique and highlights the need for improvement in covering hands during the disinfection process (28).

Hand-in-Scan™ monitoring system is a real-time objective observation and automated analysis of healthcare workers' hand hygiene practices. It has a customizable training modules, which can be integrated into the daily workflows of healthcare professionals. This not only facilitates continuous learning but also ensures that education becomes an inherent part of their routines. The system's data analysis capabilities empower healthcare facilities to monitor and assess hand hygiene compliance rates over time, offering vital insights for quality improvement initiatives. With interactive simulations, it integrates healthcare workers in realistic scenarios to actively participate in refining their hand hygiene practices. This is a multifaceted approach actively involving healthcare professionals in the learning process while providing actionable insights for continuous improvement (18, 27,29, 30).

Acbadem Health Group (AHG) maintains a reliable system for monitoring and improving hand hygiene practices, overseen by the infection control nurse. Monthly hand hygiene assessments for nurses are conducted within each department, supervised by designated individuals, typically nurses or those responsible for the respective departments, trained by the infection control nurse. All healthcare professionals undergo annual training to reinforce their understanding of hand hygiene protocols.

Employees receive regular updates and training sessions to ensure adherence to proper hand hygiene practices. Adequate infrastructure and necessary materials for effective hand hygiene are consistently provided in designated handwashing areas. Regular checks are conducted to confirm the availability and adequacy of hand hygiene materials in their designated locations. AHG employees undergo mandatory hand hygiene training annually as mandated by the Turkish Ministry of Health. Since April 2019, hand washing practices have been periodically assessed using the Semmelweis Hand Hygiene System, using this system to ensure objective evaluation of the results.

This study aims to examine nurses' hand hygiene practices before, during, and after COVID-19, assessing their effectiveness using Hand-in-Scan™ technology to explore changes over time and the pandemic's impact.

## Materials and Methods

### Study Design

The study's descriptive longitudinal multi-center design positions it to uncover meaningful patterns, trends, and diversities in hand hygiene practices across various healthcare institutions over an extended timeframe. The study spanned from April 2019 to June 2023, capturing a comprehensive overview over a four-year period.

The timeline of the study was determined according to the official pandemic start and end dates determined by the Ministry of Health in Turkey.

In the pre-pandemic period, this study was initiated to establish a baseline for hand hygiene practices and to assess the effectiveness of ongoing hygiene interventions within healthcare settings. At that time, the study aimed to evaluate routine infection control measures, without any knowledge or anticipation of an impending global pandemic. The onset of the pandemic, however, provided an unplanned but valuable opportunity to compare hand hygiene practices across different phases of healthcare delivery.

Regarding the prediction of the pandemic's start or end, it is important to note that the pandemic was an unforeseen event. The study did not originally intend to address the impact of a global health crisis. Instead, once the pandemic began, the study was adapted to assess the natural progression of hand hygiene practices in response to the heightened infection control measures implemented during the crisis.

The ethics committee approved the study as a longitudinal observational study, focusing on hygiene practices over time. The data collected during the pandemic was either prospectively gathered as part of ongoing assessments or, in some cases, retrospectively analyzed after the pandemic began to compare trends. This retrospective data analysis allowed for a comparison between pre-pandemic, pandemic, and post-pandemic periods, highlighting the lasting impact of the pandemic on hygiene behavior.

Pre-pandemic: April 2019 - March 10, 2020

Pandemic Period: March 11 - May 30, 2022

Post-pandemic: May 31 - June 1, 2023

### Sample

The study unfolded within the premises of a private healthcare institution in Turkey from 2019 to 2023, involving a total of 2253 nurses. Participants were recruited based on their willingness to take part in the study, ensuring a representative cross-section of healthcare professionals across the relevant periods. All participants were included voluntarily, and their assignment to each group was determined based on the period during which they participated in the study. No random selection or sample size calculation was applied, as this study relied on the natural flow of voluntary participation from healthcare professionals.

Group Assignment: The participants were grouped according to the timeline of the study:

1. Pre-Pandemic Group: Includes individuals whose data was collected prior to the official declaration of the COVID-19 pandemic.

2. Pandemic Group: Comprises individuals who participated during the pandemic, when infection control measures were at their peak.

3. Post-Pandemic Group: Consists of individuals whose data was collected after the pandemic, during the normalization phase.

The sample distribution comprised 936 participants from the pre-pandemic era, 892 during the pandemic and 425 post-pandemics.

#### Data Collection

Hand Hygiene Application and Data Collection Tools: The Semmelweis Scanner™ in the Hand-in-Scan System.

The study was conducted in eight hospitals within the same health group in Istanbul. The HandinScan device was transported to each hospital on a portable transfer unit and used on site. No predetermined sample size calculation was made; instead, all staff who consented to participate were included in the study.

All the participants in the study in order to use standard procedure applied a recommended 3-5 ml of (Aniosrub 85 NPC, Ecolab, France) recommended by the manufacturer alcohol-based hand disinfectant which included adye to ensure comprehensive coverage and scanning with UV from the scanner. Adhering to the World Health Organization's (WHO) six-step hand scrub procedure for uniformity, participants scrubbed thoroughly, addressing all hand areas for 15 to 30 seconds, starting with the right hand and progressing to the left. Following the hand scrub, participants placed their hands in the "Hand-in-Scan™" machine's scanner area, and the resulting scan, obtained after approximately 30 seconds, was saved automatically by the system.

This automated scanning and calculation technique ensured standard consistency and objective evaluation of hand hygiene practices across the participant cohort (8,9,28-30).

Hand-in-Scan™ calculates the efficacy of hand hygiene practices immediately with a schematic reporting. Overall report includes: Hand-in-Scan™ the Left\_palm, Right\_palm, Left\_dorsum, Right\_dorsum, and Total\_Average. This system enables both integrated education and training components to enhance healthcare workers' understanding, and learning. Thus enabling education department for customizable training modules for continuous education in the institute.

The Semmelweis Scanner allows immediate evaluation of hand sanitization with a special alcoholic hand rub solution. To achieve this, the scanner employs harmless UV-A light exposure. The system provides objective overall quality assessment scores and creates reports and statistics.

The innovative technology of the Semmelweis Scanner is made primarily for education and plays a major role in the control of Healthcare Associated Infections (HAIs).

Step-by-step guide for using the Semmelweis Scanner:

- Clean your hands with the special alcoholic hand rub according to the provided hand disinfection protocols.
- Log in using your unique identification card (RFID).
- Confirm successful identification by the system.
- Disinfect your hands following the required protocol (e.g., WHO 6-step protocol).
- Place your disinfected hands into the Semmelweis Scanner as instructed on the screen. Ensure your right hand is positioned correctly to trigger the internal sensors and spread your fingers apart as indicated.
- Once the images are recorded, withdraw your right hand and repeat these steps for the other hand.

After images of both hands are recorded, automatically the hand hygiene quality is evaluated and quick feedback on handwashing quality will be given. It considers 95% surface coverage as acceptable for both the palmar and dorsal sides of both hands separately.

The scanner identifies areas which are missed during disinfection, displaying properly covered areas in green and untreated areas in red on the screen.

The system logs out after each measurement, returning to the welcome screen for the next user.

### Data Analysis

Data analysis employed SPSS for Windows 25.0, encompassing mean, 95% Confidence Interval for Mean, 5% Trimmed Mean, Median, Variance, Standard Deviation, Minimum, Maximum, Range, Interquartile Range, Skewness, and Kurtosis. Pairwise comparisons of periods were conducted, utilizing the Independent-Samples Kruskal-Wallis Test, and Pearson Correlation was employed for relevant assessments. This structured approach provided a robust foundation for analyzing and understanding the variations in hand hygiene practices across different periods.

### Results

In the time before the pandemic period or each hand area – left palm, right palm, left dorsum, and right dorsum – we measured the average, how much the values spread out, how collected data is evenly evaluated. From the data the left palm had an average of  $96,4585 \pm 9,4199$  with a spread of 3,29; the right palm had an average of  $97,0638 \pm 9,5539$  with a spread of 2,34. Moving to the dorsum (back of the hand), the left side had an average of  $90,9236 \pm 15,7548$  with a spread of 10,86, and the right side had an average of  $88,8190 \pm 17,9436$  with a spread of 13,31. When we look at all areas combined (Total Average), it had an average of  $93,3162 \pm 11,5671$  with a spread of 7,50. These numbers help us see how hand hygiene practices were in the pre-pandemia period, giving us a clearer picture of what was happening (Table 1).

In the pandemic period we looked at key statistics to understand hand hygiene practices across different areas of the hand. The mean values give us an idea of the average cleanliness for each area: the left palm had a mean of  $99,1072 \pm 6,5115$ , the right palm had a mean of  $99,4516 \pm 5,5269$ , the left dorsum had a mean of  $97,850 \pm 8,4662$ , and the right dorsum had a mean of  $95,3369 \pm 15,5972$ . The spread of values (Interquartile Range) tells us how much the data varies, with the smallest spread seen in the right palm ( $p=0,00$ ) and the largest in the right dorsum (1,72). Asymmetry (Skewness) indicates the distribution's lopsidedness, and the tail thickness (Kurtosis) highlights how extreme values deviate from the average. These measurements collectively help us comprehend the nuances of hand hygiene practices during the pandemic period, offering valuable insights into cleanliness levels and variations across different hand regions (Table 1).

In the post-pandemia period, statistical measures to gain insights into hand hygiene practices across various regions of the hand. The mean values reflect the average cleanliness, with the left palm having a mean of  $97,8928 \pm 13,6199$ , the right palm at  $97,6470 \pm 14,3733$ , the left dorsum at  $95,8787 \pm 14,9101$ , and the right dorsum at  $95,7312 \pm 15,0932$ . The spread of values, indicated by the Interquartile Range, shows minimal variation, particularly in the palm areas where it is recorded as 0,00. Skewness, measuring the asymmetry of the distribution, ranges from -5,38 to -6,95, suggesting a relatively balanced distribution. Kurtosis, representing the thickness of the tails, ranges from 30,37 to 47,05, indicating moderate to heavy tails. Collectively, these statistical measures provide a comprehensive overview of hand hygiene practices during the post-pandemia period, offering valuable insights into the average cleanliness, variability, distribution symmetry, and extremeness of values across different hand regions (Table 1).

Table 1, the mean hand hygiene scores for various hand regions are presented, comparing pre-pandemic, pandemic, and post-pandemic periods. The scores are accompanied by standard errors, providing insights into the consistency and reliability of the recorded mean values. The hand regions include left palm, right palm, left dorsum, right dorsum, and the total average. Table 1 presents the mean cleanliness scores of different hand regions observed across the pre-pandemia, pandemic, and post-pandemia

periods. In the pre-pandemia phase, the left palm exhibited a mean score of 96,4585 with a standard error of 0,30790, while the right palm had a mean score of 97,0638 with a standard error of 0,31228.

**Table 1.** Hand hygiene mean scores across different periods and hand regions.

	Pre pandemia				Pandemia				Post pandemia			
	Mean	SD*	Std. Error	IQR**	Mean	SD	Std. Error	IQR	Mean	SD	Std. Error	IQR
<b>Left palm</b>	96,4585	9,4199	0,3079	3,29	99,1072	6,5115	0,21802	0,01	97,8928	13,6199	0,66066	0
<b>Right palm</b>	97,0638	9,5539	0,31228	2,34	99,4516	5,5269	0,18505	0	97,647	14,3733	0,69721	0
<b>Left dorsum</b>	90,9236	15,7548	0,51496	10,86	97,8509	8,4662	0,28347	0,43	95,8787	14,9101	0,72325	0,93
<b>Right dorsum</b>	88,819	17,9436	0,58651	13,31	95,3369	15,5972	0,52223	1,72	95,7312	15,0932	0,73213	1,96
<b>Total_Avarage</b>	93,3162	11,5671	0,37808	7,5	97,9366	7,7095	0,25813	0,87	96,787	14,025	0,68031	1,05

\* Std. Deviation, \*\*Interquartile Range.

Transitioning into the pandemia period, both the left and right palms demonstrated increased cleanliness, reaching mean scores of 99,1072 and 99,4516, respectively. Notably, the right palm's standard error during pandemia dropped to 0,18505, suggesting more consistent cleanliness assessments. In the post-pandemia phase, a slight decrease in mean scores was observed across all hand regions, indicating a nuanced shift in hand hygiene practices. The comprehensive overview of mean cleanliness scores and standard errors provides insights into the variations and trends in hand hygiene practices throughout the distinct periods under examination. These findings provide a nuanced understanding of the mean values and their variations, contributing valuable insights into the dynamics of hand hygiene practices over the specified periods.

**Table 2.** Pairwise comparisons of hand hygiene scores between different periods.

Pairwise Comparisons of Period	Test Statistic	Std. Error	Std. Test Statistic	p	Adj. Sig.
<b>Pre-Pandemia vs. Pandemia</b>	-653,358	30,176	-21,652	0,000	0,000
<b>Post-Pandemia vs. Pandemia</b>	19,785	38,011	0,521	0,000	0,000
<b>Pre-Pandemia vs. Post-Pandemia</b>	-633,573	37,721	-16,796	0,603	1,000

\*post-hoc Tukey HSD, \*\*Post-hoc çiftler arası karşılaştırma testi.

Table 2 illustrates the statistical comparisons between hand hygiene scores across different periods, including pre-pandemia, pandemia, and post-pandemia.

**Pre-Pandemia vs. Pandemia:** This comparison demonstrates a highly significant difference between hand hygiene practices in the pre-pandemic and pandemic periods. The negative test statistic indicates a substantial decrease in hand hygiene practices during the pandemic.

**Post-Pandemia vs. Pandemia:** This comparison reveals a statistically significant difference between hand hygiene practices in the post-pandemic and pandemic periods. The positive test statistic suggests an increase in hand hygiene practices post-pandemia.

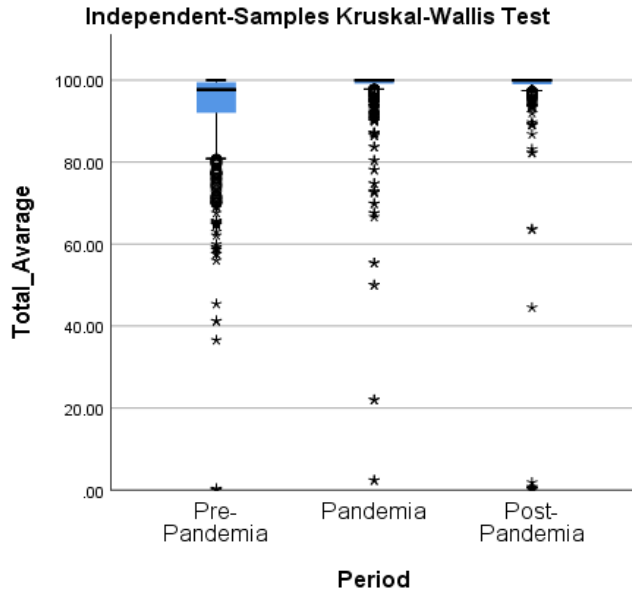
**Pre-Pandemia vs. Post-Pandemia:** In this comparison, there is no statistically significant difference between hand hygiene practices in the pre-pandemic and post-pandemic periods. The high p-value (0,603) suggests that any observed difference is likely due to random variation, and it is not statistically significant. The adjusted significance is 1,000, further supporting the lack of significance.

This graphic visually represents the outcomes of the Kruskal-Wallis test, highlighting significant differences in hand hygiene scores between the "Pre-Pandemia vs. Post-Pandemia" and "Pre-Pandemia vs. Pandemia" groups. Notably, no significant difference was observed between the "Post-Pandemia vs. Pandemia" groups.

The positive linear association between "Total\_Average" and "Right\_dorsum," indicated by a Pearson correlation coefficient of 0,885, is statistically significant at the 0,01 level (2-tailed). This implies that variations in "Total\_Average" are consistently linked with corresponding variations in "Right\_dorsum," demonstrating a compelling pattern of co-variation between these two variables.

Similarly, the Pearson correlation coefficient of 0,909 between "Total\_Average" and "Left\_dorsum" highlights a strong and statistically significant positive linear association. This correlation, significant at

the 0,01 level (2-tailed), emphasizes a high degree of co-variation between the two variables. The pattern suggests that as "Total\_Average" increases, there is a tendency for "Left\_dorsum" to increase as well, and vice versa.



**Graphic 1.** Kruskal-Wallis test results for hand hygiene scores across different periods.

## Discussion

Our study evaluated the intricacies of hand hygiene practices across distinct periods, illuminating significant trends and variations in mean cleanliness scores. The meticulous analysis of data collected during pre-pandemia, pandemic, and post-pandemia periods offered valuable insights into the evolving landscape of hand hygiene practices.

During the pre-pandemia phase, sample size of 936 instances, with the mean cleanliness score set a baseline at 93,32, served as a reference point. This allowed us to assess subsequent shifts in hand hygiene practices. Notably, our investigation revealed a substantial increase in mean cleanliness during the pandemic period, with 892 instances and a resulting mean score of 97,94. This upward trend underscored the heightened emphasis on hygiene protocols during the pandemic, indicative of increased awareness and adherence to hand hygiene practices.

In the post-pandemia period, covering 425 observations, the mean cleanliness experienced a slight decrease to 96,79. While this decline is noteworthy, the overall cleanliness levels remained notably high compared to the pre-pandemia baseline. The detailed breakdown of mean cleanliness scores for different hand regions, complemented by corresponding 95% Confidence Intervals, provided nuanced insights into expected cleanliness levels during each period.

Across the entire observed period, pre-pandemia, pandemic, and post-pandemia phases, mean cleanliness scores for various hand regions consistently remained in high percentage. The 95% Confidence Intervals instilled confidence in the accuracy of these mean estimates, offering a comprehensive understanding of cleanliness levels throughout the study duration.

A comparison between the pre-pandemic, pandemic, and post-pandemic periods, emphasizing notable alterations during the pandemic. This is evidenced by a considerable negative test statistic and a p-value of 0.000. The post-pandemic period exhibits a slight, statistically significant divergence from the pandemic period, suggesting the persistence of some effects. However, there is no notable distinction between the pre- and post-pandemic periods, indicating a return to pre-pandemic conditions. This

suggests that while the pandemic had a notable impact, the post-pandemic period reverted to earlier states (Table 2).

Drawing insights from literature, Ghorbanmovahhed et al.'s (2023) study sheds light on the effectiveness of an infection control link nurse program, emphasizing its role in improving compliance with standard precautions and hand hygiene among nurses. Using the "Compliance with Standard Precautions Scale" (CSPS) and the World Health Organization observational hand hygiene form, the study found commendable adherence with mean scores of 97,78 for the left palm, 98,12 for the right palm, 94,60 for the left dorsum, 92,70 for the right dorsum, and an overall average of 95,80. Robust 95% Confidence Intervals underscored the reliability of these findings, enriching our understanding of anticipated cleanliness levels across various hand areas throughout the observation period. This research is particularly relevant as it directly correlates with hand hygiene compliance and, consequently, influences mean cleanliness scores across diverse hand regions (26).

Alci et al. reported a 70% improvement among nurses in their study using Semmelweis system hand in scan. In particular, fingertips were the most frequently missed areas, while palms were the least frequently missed (30).

Despite the advancements in technology for hand hygiene contribute valuable insights into various aspects of hygiene (16, 17, 25, 27, 31-35). Immediate indicators of hand cleanliness are still limited, presenting an area where further innovation could enhance infection prevention strategies (1,4,7-9,15,16,18, 21, 23- 27, 29,35).

While a multitude of studies provide valuable contributions to the broader landscape of hygiene and healthcare practices, a careful selection based on their direct relevance to the mean cleanliness scores across distinct hand regions is crucial for a focused and impactful analysis. Recognizing and addressing these diverse factors not only fortifies clinical practice by promoting effective hand hygiene practices and mitigating the spread of infections but also ensures the provision of precise and trustworthy measurements through the advanced capabilities of Hand-in-Scan™. This integration enhances the visibility of interventions and facilitates constructive feedback, contributing to an overall improvement in hand hygiene compliance and infection control measures within healthcare settings.

#### Limitation of study

The study is subject to several limitations. Firstly, it was conducted in a single private health facility in Turkey, which may limit the generalisability of the findings to other settings. Secondly, participation was voluntary, which could potentially create selection bias as those more interested in hand hygiene were more likely to participate. Thirdly, the observational nature of the study limited the ability to establish causality between interventions and outcomes. Finally, reliance was placed on self-reported data and differences in individual practices.

#### Conclusion and Suggestions

This study examined hand hygiene practices across different time periods, revealing significant trends. While the pandemic period showed a notable increase in mean hand hygiene, post-pandemic levels remained high. The findings of this study demonstrate that the pandemic had a considerable impact on practices, yet the post-pandemic period saw a return to pre-pandemic conditions. This suggests that the changes observed during the pandemic were, at least in part, temporary. The study acknowledges the role of Hand-in-Scan™ technology in providing precise and trustworthy measurements, enhancing the visibility of interventions, and facilitating constructive feedback. This integration contributes to overall improvement in hand hygiene compliance and infection control measures within healthcare settings.

#### Implications for Practice

This study highlights the effectiveness of hand hygiene practices, particularly during the pandemic, with a sustained improvement observed in the post-pandemic period. The use of advanced technology such as Hand-in-Scan™ has further standardized and enhanced the accuracy of hand hygiene measurements.

This integration contributes to continuous improvements in compliance and overall hygiene standards within healthcare environments, ultimately supporting better infection control outcomes.

**Ethical Statement:** Since this article is a sharing of experience, the management of the institution was duly informed before publication and permission was given to disseminate this information. Ethical approval was not obtained for this publication as it does not contain personal data.

**Authors Contributions:** Manuscript concept/design: SKA – Data collecting: SKA, ASK, GB, NŞÇ – Data analysis/review: SKA, ASK, GB, NŞÇ – Writing the manuscript: SKA, ASK, GB, NŞÇ – Critical review of content: SKA, ASK – Final approval and responsibility: SKA, ASK – Material and technical support: SKA, ASK, GB, NŞÇ – Supervision: SKA.

**Peer Review:** External independent.

**Conflict of Interest:** The authors of this article declare no conflict of interest.

**Financial support:** The author declare that the study has no financial support.

**Acknowledgments:** We extend our sincerest appreciation to all participants who graciously contributed to this research endeavor.

**Other Declarations:** The study was presented as an oral presentation at the 1st National Health Sciences Congress of Istanbul Sebahattin Zaim University and was awarded the Best Oral Presentation accolade.

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