Scientific Research Publishing

International Journal of Otolaryngology and Head & Neck Surgery, 2026, 15(1), 66-78
https://www.scirp.org/journal/ijohns
ISSN Online: 2168-5460
ISSN Print: 2168-5452

The Effects of Alcohol-Based Hand Sanitizer and Cologne Use on Blood Alcohol Levels and Nasal Functions

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How to cite this paper: Sökmen, A. and Tatar, A. (2026) The Effects of Alcohol-Based Hand Sanitizer and Cologne Use on Blood Alcohol Levels and Nasal Functions. *International Journal of Otolaryngology and Head & Neck Surgery*, **15**, 66-78.
https://doi.org/10.4236/ijohns.2026.151007

Received: November 14, 2025
Accepted: January 19, 2026
Published: January 22, 2026

Abstract

Objective: This study aims to investigate the effects of alcohol-based hand sanitizers (ABHS) and cologne, which are widely used in infection control, on blood alcohol level and nasal functions. **Methods:** Sixty volunteer healthcare workers were included in this prospective study conducted at Atatürk University Faculty of Medicine. Participants were divided into three groups: hand sanitizer users, cologne users, and a control group. Serum ethanol levels, nasal function tests (VAS score, rhinomanometry, saccharin test), and nasal culture results were evaluated in all participants before and after the study. **Results:** Total nasal airway resistance did not differ significantly between groups ($p > 0.05$). The mucociliary clearance time increased slightly in both groups after exposure. A significant increase in serum ethanol levels was found after the use of hand sanitizer ($p < 0.05$) and no statistically significant difference was observed between the cologne and control groups ($p > 0.05$). A decrease in bacterial colony count was observed in nasal cultures after the use of both products ($p < 0.05$). While VAS scores increased significantly with the use of hand sanitizer ($p < 0.05$), no statistical difference was observed, despite a quantitative increase in cologne use. A slight increase in the endoscopic score was observed after hand sanitizer use, whereas minimal or no change was noted after cologne user group. **Conclusion:** Use of alcohol-based hand sanitizer and cologne increases serum ethanol levels to detectable levels and causes changes in some nasal parameters with short-term use. However, these changes are not at a pathological level. Both products have an effect of reducing nasal bacterial colonization.

Keywords

Alcohol-Based Hand Sanitizer, Cologne, Serum Ethanol Level, Nasal Function, Mucociliary Clearance

1. Introduction

The use of hand sanitizers is one of the most effective methods for infection control. Especially with the COVID-19 pandemic, these products have become widespread not only among healthcare workers but also in the general public [1] [2]. To prevent the spread of infection, the World Health Organization (WHO) recommends frequent hand washing with soap or the use of hand sanitizers containing at least 60% alcohol [3]. Hand sanitizers recommended by the WHO and the Centers for Disease Control and Prevention (CDC) fundamentally contain different combinations of ethanol, isopropyl alcohol, n-propyl alcohol, and hydrogen peroxide [4]-[9]. However, the misuse of these products can lead to toxic effects on human health [3]. During the use of ethanol-based hand sanitizers (ABHS), a small amount of alcohol can be absorbed via the transdermal route and detected in the blood [1] [4] [7] [8] [10]. In addition to dermal contact during antisepsis, exposure to alcohol also occurs via the inhalation route [7] [11] [12]. In studies examining the effects of direct oral intake of alcohol on nasal functions, it has been shown that alcohol creates edema in the nasal mucosa and increases nasal resistance through a peripheral vasodilator effect and by suppressing catecholamine release in the central nervous system [13] [14].

Although the literature contains studies demonstrating the negative effects of systemic alcohol use on nasal functions, there is no study investigating the effects of alcohol exposure via skin and inhalation due to ABHS and cologne use on nasal functions. Therefore, the aim of our study is to investigate the effects of ABHS and cologne, used to prevent the spread of infections, on blood alcohol level and nasal functions.

2. Methods

This study was conducted with the approval of the Atatürk University Faculty of Medicine Research and Training Hospital Ethics Committee. A total of 60 volunteer healthcare workers, over 18 years old, with a mean age of 27.5, and comprised of 33.3% female and 66.7% male participants, were included in the study. Participants were informed about the study and provided written consent. Individuals with allergies to hand sanitizer or cologne, chronic sinusitis or allergic rhinitis, or those who were pregnant or suspected of pregnancy were excluded.

Volunteers were divided into three groups:

1. Group: Hand sanitizer users (n = 20)
2. Group: Cologne users (n = 20)
3. Group: Control group (n = 20)

Participants were instructed to abstain from alcohol-containing food, perfume, and sprays for at least 12 hours before and during the study. In the first group, Poviexin (hand and skin antiseptic, contains:70 % ethyl alcohol, CAS No:64-17-5, glycerin and colorant) hand sanitizer containing 70% ethanol was used approximately 25 times at about 2 mL during an eight-hour working period. After applying the product to the hands, it was rubbed until dry. To prevent inhalation, it was

ensured that the product was applied at least 30 cm away from the nose. In the second group, cologne containing 70% ethanol was used 25 times. Participants sprayed a total of 2 mL of cologne onto their right and left hands, rubbed their hands, and finally sniffed the product.

Venous blood samples were taken from both groups twice: before and after the application. Additionally, the VAS questionnaire, endoscopic examination, rhinomanometry, saccharin test, and nasal culture were performed. In the control group, the same evaluations were performed at the end of the eight-hour period.

2.1. VAS Scale (Visual Analogue Score)

A questionnaire scored from 0 - 10 was used to evaluate nasal congestion, runny nose, reduced sense of smell, and headache/facial pressure.

2.2. Endoscopic Examination

Parameters of nasal discharge, inflammation, and edema were scored between 0 - 2.

2.3. Serum Ethanol Levels

Venous blood samples (3 mL) were taken from the antecubital fossa into biochemistry tubes and stored at +4˚C. Measurements were performed using a photometric method on a Roche Cobas c702 (Roche Inc., Tokyo, Japan) device, and results were recorded in mg/dL.

2.4. Nasal Resistance

Active anterior rhinomanometry was applied to evaluate nasal airway resistance. Measurements were performed at 150 Pascal pressure according to the criteria of the European Rhinomanometry Standardization Committee. Total nasal resistance was obtained by calculating the right and left inspiratory resistances.

2.5. Mucociliary Clearance

The saccharin transit time test (STT) was applied. A 1/4 dose of 1.25 mg sodium saccharin tablet was placed on the medial surface of the inferior turbinate with the aid of a rigid endoscope. Participants were reminded not to eat, cough, sneeze, or talk during the test. The time until the taste was felt in the back of the tongue was recorded in minutes.

2.6. Nasal Culture

A swab sample was taken from the right nasal vestibule of each participant. Samples were vortexed in 1 mL of saline (SF), then surface plated and incubated for 24 hours at 35˚C - 37˚C. Colonies were counted, and results were calculated as the number of colonies per mL. A rapid test was used for the identification of staphylococci.

2.7. Statistical Analysis

Data were analyzed using SPSS 25.0 (IBM Corp., Armonk, NY, USA) program. Nor-

mal distribution was assessed with the Kolmogorov-Smirnov test. The t-test was used for two-group comparisons, and ANOVA and Fisher's LSD test were used for three-group comparisons. Statistical significance was accepted as $p < 0.05$.

3. Results

No significant difference was found in age and sex distribution among the three groups included in the study ($p > 0.05$).

3.1. Total Nasal Airway Resistance (TNAR)

The mean total nasal airway resistance (TNAR) did not show a statistically significant change after the use of alcohol-based hand sanitizer or cologne. In the sanitizer group, TNAR remained stable (0.17 ± 0.02 Pa/cm³/s before and 0.17 ± 0.02 after use), while in the cologne group it slightly increased (0.17 ± 0.04 to 0.19 ± 0.04 Pa/cm³/s, $p = 0.15$), no meaningful difference was observed compared to the control group (Figure 1).

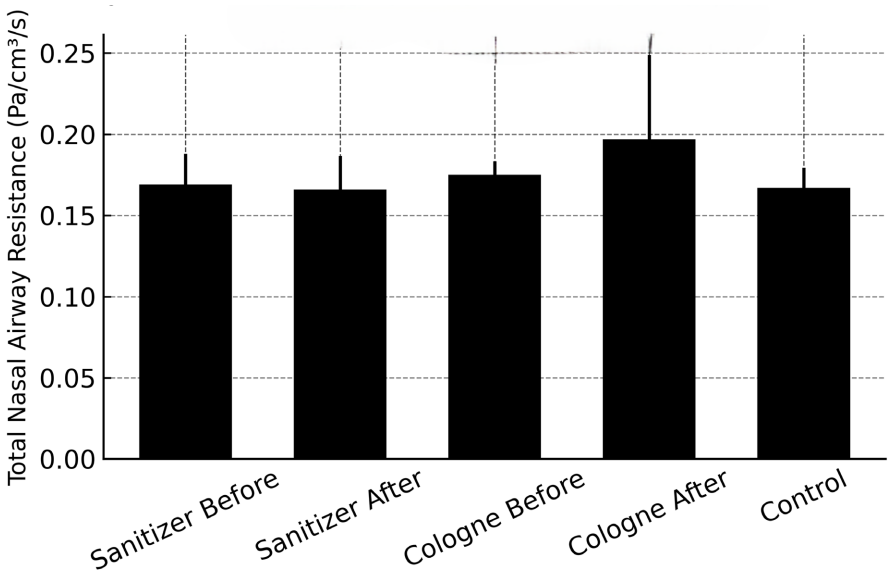

Figure 1. Total Nasal Airway Resistance (TNAR) before and after use of hand sanitizer and cologne compared with control group.

3.2. Mucociliary Clearance Time

The sanitizer group showed a mean increase from 5.8 ± 2.2 to 6.9 ± 2.4 minutes, and the cologne group from 6.6 ± 3.7 to 8.5 ± 4.0 minutes. The mucociliary clearance time increased slightly in both groups after exposure; when compared with prior to the being used products, the change was statistically significant ($p < 0.05$). In control group the STT means was 6.2 ± 2.4 and an increasing time was observed in both the hand sanitizer and cologne groups compared to the control group. However, this increase in duration was not statistically significant in hand sanitizer group ($p > 0.05$); in contrast, a significant increase was observed in the cologne user group ($p < 0.05$) (Figure 2).

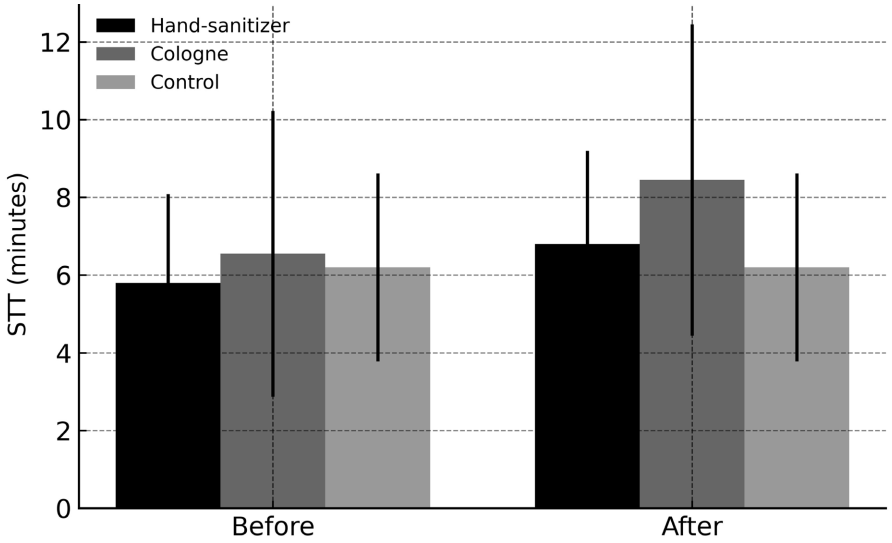

Figure 2. Mucociliary Clearance Time (STT- Saccharin Transit Time) before and after use of alcohol-based hand sanitizer and cologne compared with control group.

3.3. Serum Ethanol Levels

Mean serum ethanol levels increased slightly after sanitizer use (from 3.8 ± 3.3 to 4.4 ± 3.4 mg/dL) and after cologne exposure (from 2.5 ± 3.5 to 2.9 ± 3.9 mg/dL), that has statistical significance ($p < 0.05$). The mean serum ethanol levels in the control group were 1.3 ± 1.3, and when compared with the control group, the mean serum ethanol levels in the hand sanitizer group increased and were found to be statistically significant ($p < 0.05$), but although ethanol levels increased quantitatively in the cologne group, they were not found to be statistically significant ($p > 0.05$), (**Figure 3**).

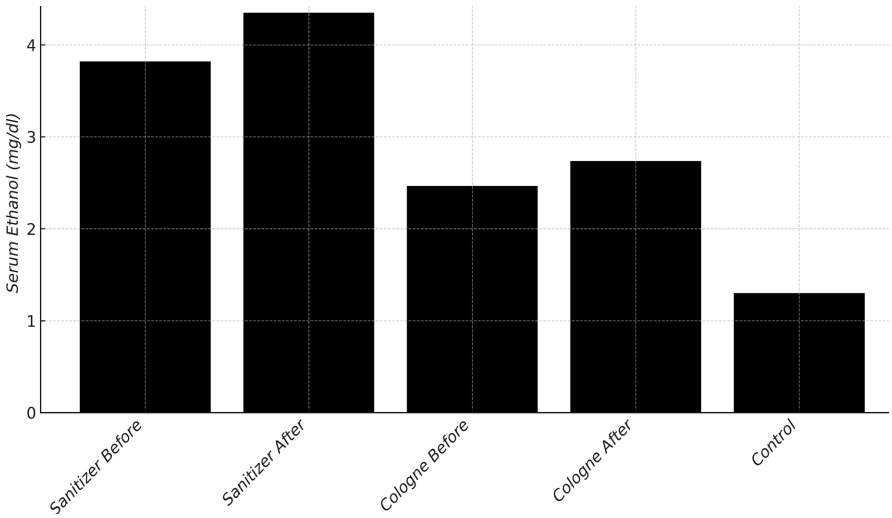

Figure 3. Blood Alcohol Levels before and after use of hand sanitizer and cologne compared with control group.

3.4. Nasal Culture

Bacterial colony counts expressed as log10 CFU decreased in both groups after

exposure to sanitizer and cologne (Figure 4). Mean colony counts were 29,250 ± 67,397 CFU in the sanitizer group and 14,820 ± 14,919 CFU in the cologne group and 63,125 ± 54,118 in control group. A significant difference was found in the comparison of before and after the use of hand sanitizer and cologne ($p < 0.05$). A significant decrease was also found in the post-use values of both products when compared to the control group ($p < 0.05$). The most frequently isolated bacteria was coagulase-negative staphylococcus (CoNS). A decrease in bacterial colony counts was observed in all cultures after hand sanitizer and cologne use.

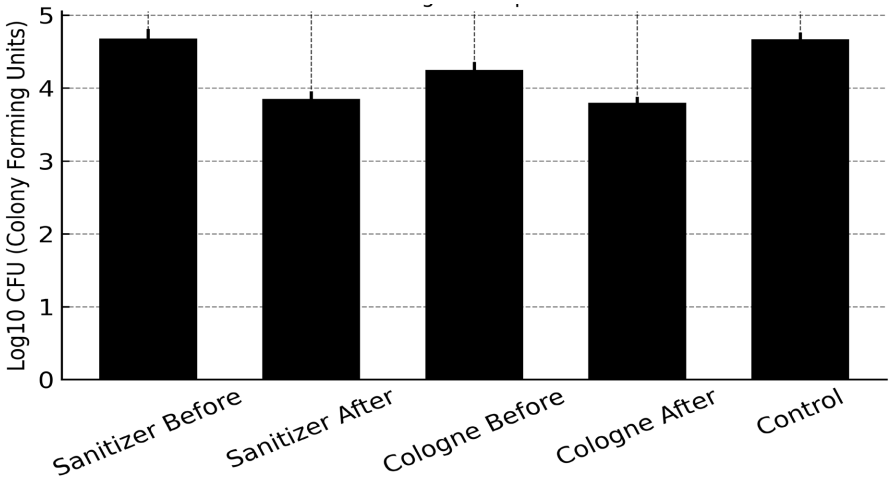

Figure 4. Nasal Culture (CFU, log10) before and after use of hand sanitizer and cologne compared with control group.

3.5. VAS Score

The visual analogue scores showed mild variations after product use (Figure 5). VAS increased from 0.5 ± 1.5 to 2.3 ± 3.0 after sanitizer exposure and 0.5 ± 1.5 from 1.0 ± 2.05 after cologne exposure. Although a mild quantitative elevation was detected in both groups, when compared with control group a statistically significant increasing was in hand sanitizer group ($p < 0.05$), in contrast to cologne group in which was not statistically significant ($p > 0.05$).

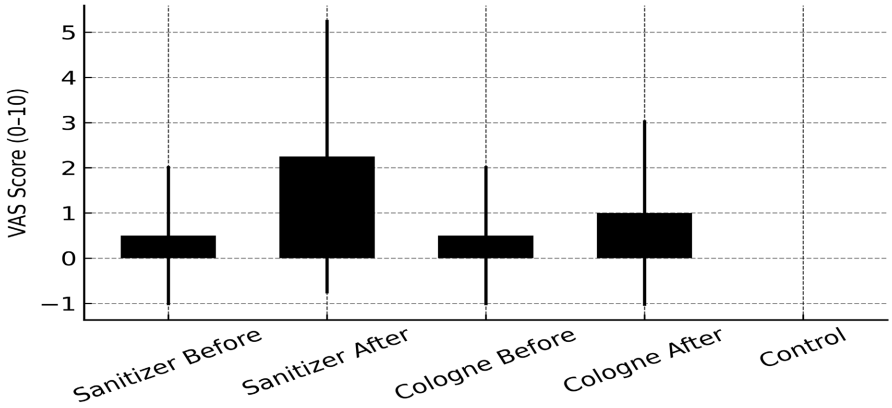

Figure 5. Visual Analogue Scores (VAS) before and after use of alcohol-based hand sanitizer and cologne compared with control group.

3.6. Endoscopic Scores

Figure 6 shows the mean ± standard deviation (SD) of endoscopic scores measured before and after the use of alcohol-based hand sanitizer and cologne, compared with the control group. A slight increase in the endoscopic score was observed after hand sanitizer use, whereas minimal or no change was noted after cologne user group. No difference was found in the cologne group ($p > 0.05$). When compared to the control group, there was a significant difference only in the post-use values of the hand sanitizer group ($p < 0.05$).

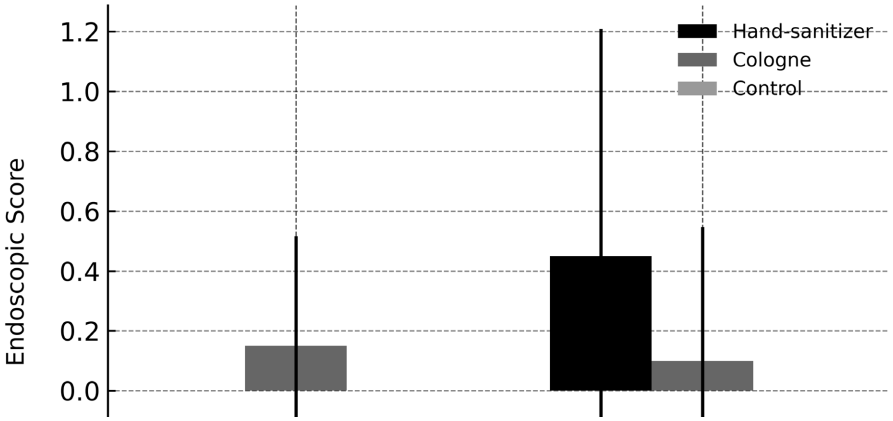

Figure 6. Comparison of endoscopic scores before and after use of alcohol-based hand sanitizer and cologne compared with control group.

3.7. Inter-Group Comparisons

Comparative analysis of the post-hand sanitizer and post-cologne groups demonstrated no statistically significant differences across TNAR, STT, VAS, endoscopic score, nasal culture, or serum ethanol levels ($p > 0.05$) (Figure 7).

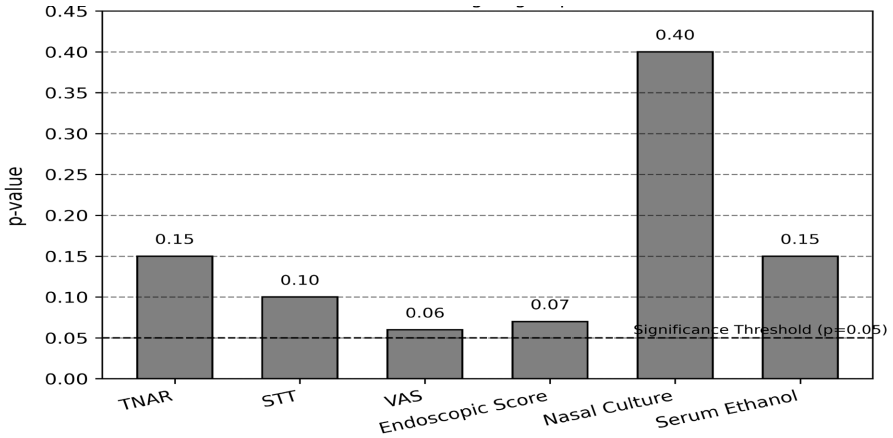

Figure 7. Comparison of nasal functional parameters and serum ethanol levels, after use of alcohol-based hand sanitizer and cologne.

4. Discussion

During hand antisepsis, healthcare workers may be exposed to various alcohols

through inhalation and skin contact [7]. The frequent use of alcohol-based solutions in the hospital environment raises concerns among healthcare workers regarding the systemic effects of alcohol [9] [15]. Intensive use of these preparations can pose a potential risk [4]. Clinically toxic effects of alcohol are headache, blurred vision, nausea, vomiting, abdominal pain, lethargy and hypotony [5] [16]. On the other hand, frequent use of hand sanitizer can cause local skin problems such as skin damage and chronic contact dermatitis [17] [18]. In our study was not observed any skin adverse effects. This is likely due to the glycerin content in the hand sanitizer, which acts as a moisturizer.

It is known that blood alcohol levels vary among individuals depending on sex, body weight, and the amount of alcohol consumed [13]. Previous studies have reported that alcohol used for disinfection is partially absorbed, can be detected in the blood, and may show toxic effects. Vivier *et al.* reported the development of toxicity in a 21-day-old infant whose mother used 70% isopropyl alcohol for umbilical dressing [16] [19]. However, no toxic effect was observed in the participants in our study despite the use of hand sanitizer and cologne.

Different views exist in the literature regarding the effect of alcohol exposure on serum levels. Kramer *et al.* found small, dose-dependent increases in blood alcohol levels after the use of hand- sanitizers containing three different concentrations of ethanol (95%, 85%, and 55%) [9]. Brown *et al.* also reported that a low amount of ethanol could be detected in the serum with intense and repeated use of hand-sanitizers containing 70% ethanol and isopropanol. However, they did not specify whether this increase was via the transdermal or inhalation route [20]. Other studies have also reported an increase in blood levels after topical application, emphasizing that the inhalation route cannot be excluded [21]-[23]. In our study, an increase in serum ethanol levels was found after the use of both hand sanitizer and cologne. However, the increase in the cologne group was not statistically significant when compared to the control group. The higher serum ethanol levels found in hand sanitizer users may be attributed to the higher alcohol content in the products used. In some studies, no increase in serum alcohol levels has been reported after transdermal or inhalation exposure. Brugnone *et al.* have not detected isopropanol in the blood of paint workers after isopropanol exposure but found it in the exhaled breath, explaining this with a large volume of distribution [24]. Hautemaniere *et al.* have not detected alcohol in the blood and urine of healthcare personnel working with hand-sanitizers containing 70% ethanol [11]. Similarly, Ahmed-Lecheheb *et al.* have not found alcohol in the blood and urine of 86 healthcare workers after using ethanol- containing hand-sanitizers [4]. Miller *et al.* also stated that there was no increase in serum levels with four hours of intensive use of a hand-sanitizers containing 62% ethanol [25]. The finding of an increase in our study, contrary to these studies, may be explained by the long duration of exposure and the high alcohol content.

Some publications state that ethanol in alcohol-based solutions is mainly absorbed by inhalation, and transdermal absorption is limited [26]-[28]. Kirschner and Lang reported no transdermal absorption in randomized double-blind studies

[8] [15]. Conversely, Turner *et al.* showed that isopropyl alcohol could be absorbed through healthy human skin [29]. In our study, serum ethanol levels were found to be lower in the cologne group compared to the hand sanitizer group, despite sniffing the product after rubbing the hands. This is likely related to the variability in the ethanol content of cologne. Berkkan *et al.* found the ethanol content in 19 different colognes to be between 37% and 98% in their study during the pandemic [30]. Furthermore, as our study was conducted under pandemic conditions, the volunteers' use of masks may have limited the absorption of cologne via inhalation.

Inhaled alcohols are rapidly distributed due to their high solubility and increase swelling and resistance in the nasal mucosa by suppressing sympathetic activity through a depressant effect on the central nervous system [11] [13] [14] [31]. However, no significant change in total nasal resistance measured by rhinomanometry was found after the use of either hand sanitizer or cologne in our study. This result suggests that exposure via the skin and inhalation is not as effective as alcohol consumption via the oral route. The fact that the obtained values remained within the limits considered normal in the literature shows that alchol-based hand sanitizers and cologne do not pathologically affect nasal resistance [31].

The increased VAS scores in the hand sanitizer group can be explained by the psychological effect due to the irritating odor of the chemical components in the products. The lack of change in VAS scores in the cologne group may be attributed to the pleasant scent, which does not create a negative perception. The inconsistency between VAS and endoscopic scores and the objective measurement of rhinomanometry has also been previously reported in the literature [32] [33].

Mucociliary clearance is the primary defense mechanism of the airway and can be practically measured with the saccharine test [34]-[36]. Animal studies have reported reduced mucus transport at high alcohol levels, while effects in humans are variable [37]-[39]. In our study, although a prolongation in the group-specific mucociliary clearance time was observed in hand sanitizer users, no significant difference was found compared to the control group. In the cologne group, although the time was prolonged, it did not reach the pathological limit [40]. These results suggest that neither product impairs mucociliary function at a clinically significant level.

Nasal flora plays an important role in infection control. Staphylococcus aureus, which is part of the normal flora, carries the risk of nosocomial infection due to its carriage in healthcare workers [41] [42]. In our study, S. aureus carriage was found to be 35%, which is consistent with the literature. The reduction in bacterial colony count in nasal cultures by hand sanitizer and cologne is an indicator of their antiseptic effects. This finding is also supported by previous studies [43] [44].

The protocol of 25 applications within an 8-hour period was designed to reflect intensive yet clinically realistic hand hygiene practice among healthcare workers. Observational studies have reported that healthcare workers experience approximately 20 - 100 hand hygiene opportunities per shift, depending on clinical setting

and workload, with higher frequencies in intensive care and emergency units [45]-[47]. Accordingly, the selected frequency represents the upper range of routine clinical practice rather than an exaggerated exposure, allowing assessment of systemic and nasal effects under real-world intensive-use conditions and enhancing the external validity of the findings.

5. Conclusion

Use of alcohol-based hand sanitizer and cologne increases detectable serum ethanol levels and causes changes in some nasal parameters with short-term applications. However, these changes are not at a pathological level. It was concluded that alcohol-based hand sanitizers and cologne hold an important place in infection control due to their effect of reducing nasal bacterial colonization.

Informed Consent

Written informed consent was obtained from all participants.

Ethics Statement

The study was approved by the Atatürk University Faculty of Medicine Ethics Committee.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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