

## Research Paper

# Adverse Effects Induced by Long-term Use of Hand Sanitizers Among Health Staff During COVID-19



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## ABSTRACT

**Background:** The present study examines the various complications and impurities of alcohol-based hand sanitizers during COVID-19 among health workers in Hamadan City, Iran.

**Methods:** This cross-sectional study was conducted on 178 healthcare workers in different hospitals affiliated with the Hamadan University of Medical Sciences. The inclusion criteria included health personnel working in hospitals dedicated to the care and treatment of patients with COVID-19 in Hamadan City. A researcher-made questionnaire was used to collect data. Afterward, to evaluate the quality and impurities of the alcohol-based hand sanitizers used by healthcare workers, various samples were collected and analyzed using gas chromatography-mass spectrometry (GC-MS). Stata software version 14-2 was used to analyze the data.

**Results:** The highest and the lowest percentages of ethanol in washing solutions and gels were 68.24% and 60.71%, respectively. Among them, the frequency of using gel, solution, and spray was 93.82%, 42.13%, and 49.44%, respectively. Skin and breathing sensitivity were the most common symptoms in 44.38% and 27.68% of the health workers, respectively. Skin dryness (50%) and sore throat (25.84%) were the most common complications observed in skin and respiratory symptoms among health workers, respectively.

**Conclusion:** The prevalence of various complications related to the use of alcohol-based hand sanitizers is high among health workers, which highlights the role of using appropriate alcohol-based hand rubs with suitable formulations in the hospital environment to reduce the adverse health effects caused by their long-term and extensive use among health workers.

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## 1. Introduction

**C**oronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has rapidly spread around the world [1, 2]. COVID-19 is a dangerous disease with an unclear mechanism that primarily spreads via respiratory droplets [3]. The main symptom of the flu-like disease is acute respiratory pneumonia which varies widely among affected people [4, 5]. Transmission of infection can occur by infected or asymptomatic individuals. It is also widely transmitted via contact with contaminated objects or surfaces [6]. During the COVID-19 epidemic, the need to care for patients for long hours in unsafe environments and close interaction with them can create a state of anxiety for healthcare workers [7]. Previous studies have shown that the intensity of exposure has a critical role in the infection of healthcare workers [8]. Up to now, no specific treatment is available to fight COVID-19 infections. Therefore, using infection prevention measures among healthcare workers can increase their enthusiasm for overwork and reduce the severity of anxiety in them. Wearing a face mask, using hand sanitizer and surface disinfectants, such as diluted oxygenated water or alcoholic solutions with different formulations, appropriate environmental disinfectants are crucial infection control tools that can reduce the load of the virus particles and disease transmission in the healthcare workers [9]. It is quite clear and also as mentioned in previous studies, frequent hand washing with alcohol-based hand rubs as well as long-term use of personal protective equipment in patient care can cause skin complications, such as eczema, irritant contact dermatitis, inflammation, secondary infections, aggravation of skin damage, and skin dryness among healthcare workers [10-12]. Based on a previous study conducted by Lan et al., in 2020, the prevalence of adverse effects on the skin and mucous membrane barrier among health care workers was related to long-term and extensive use of prevention measures [13]. Another concern regarding the use of alcohol-based hand rubs for hand disinfection as the first choice among health care workers is related to the purity of the raw material as well as the presence of impurities in their formulations [14]. According to the European Pharmacopoeia, methanol, acetaldehyde, benzene, and non-volatile compounds are vital impurities in alcohol-based hand rubs [15]. The use of alcohol-based hand rubs with unsuitable formulations and high impurity in addition to inefficiency is associated with a wide range of problems among health care workers. A study using 100% n-propanol solution

in alcohol-based hand rubs can cause skin irritation [2]. Given the direct exposure of healthcare workers in hospitals to COVID-19 patients, they are at higher risk for skin damage caused by the long-term and extensive use of alcohol-based hand sanitizer rubs in the hospital environment. Until now, few studies have been conducted on the respiratory, neurological, and gastrointestinal complications caused by the use of alcohol-based hand sanitizers during COVID-19 among healthcare workers in Iran. Therefore, the present study aimed to evaluate various complications caused by the use of alcohol-based hand sanitizers in hospital environments which are commonly used by healthcare workers in Hamadan City, Iran. Moreover, to investigate the quality and impurities of these sanitizers, various samples were collected and analyzed using a gas chromatography-mass spectrometry (GC-MS) instrument.

## 2. Materials and Methods

This cross-sectional study was conducted on 178 active healthcare staff in various wards, such as the intensive care unit (ICU), laboratory, radiology, and photography of [Hamadan University of Medical Sciences](#) hospitals from June 1, 2020 to September 30, 2020. The inclusion criteria included all the healthcare staff in different wards of the dedicated COVID-19 public hospitals in Hamadan City. The exclusion criteria included having prior problems, such as skin, respiratory and neurological allergies to alcoholic sanitizers. The protocol of this study was approved by the ethical code of [Hamadan University of Medical Sciences](#) (Code: IR.UMSHA.REC.1399.234).

The tools used in the research were a researcher-made questionnaire, including demographic characteristics, skin symptoms (such as skin irritation, itching, skin dryness, and inflammation), respiratory symptoms (such as cough, itching throat, frequency cough, and sore throat), neurological symptoms (such as vertigo, headache, and anxiety) and gastrointestinal symptoms (such as vomiting, diarrhea, and heartburn).

Then, various samples of alcohol-based hand sanitizers, such as gel, spray, and wash solution provided by the participants or the hospital were collected and transferred to the forensic laboratory in Hamadan Province for analysis using a gas-chromatography device.

### Ethanol analysis

Ethanol analysis was performed by gas chromatography (GC, CP3800, Varian Technologies, and Kyoto, USA) with a flame ionization detector (FID). Ethanol

separation was conducted on a BD5 capillary column (40 m×0.18 mm I.D. and 0.18 µm film thicknesses, Agilent Technologies, USA). Helium gas with high purity (99.9999% purity) and a flow rate of 5 mL/min was utilized as the carrier gas. The initial temperature of the oven was set at 55°C. It maintained at this temperature for 5 minutes, and then the oven temperature increased to 120°C with a rate of 30°C per minute and finally remained at this temperature for 4 minutes. Some samples with unknown peaks were analyzed using a gas chromatography-mass spectrometry (GC-MS) device for qualitative analysis.

### Method validation

Before analyzing the ethanol in the collected samples, the linear dynamic range (LDR), accuracy, calibration curve, limits of detection (LOD), and limit of quantification (LOQ) of the method were determined and investigated to show the validity of the analytical procedure. The concentrations corresponding to the peak area responses with signal-to-noise (S/N) ratios of 3 and 10 were considered as LOD and LOQ, respectively.

### Study statistical analysis

The qualitative data were summarized based on frequency, percentage, and quantitative variables with mean ± standard deviation. Statistical analysis was performed using the Chi-square test to evaluate the relationship between alcohol-based disinfectant use with the skin, respiratory, neurological, and gastrointestinal adverse effects in healthcare workers. Stata software version 14-2 was used to analyze the data. P value less than 0.05 was considered significant.

**Table 1.** Baseline characteristics of studying the population

Variable	Category	No. (%)
Gender	Male	84(47.46)
	Female	93(52.54)
Age (y)	20-34.9	101(56.74)
	35-49.9	65(36.52)
	50+	12(6.74)
	Diploma	27(15.17)
Education	Associate degree	8(4.49)
	Bachelor of Science	108(60.67)
	Master of Science	35(19.66)

## 3. Results and Discussion

In the present study, a total of 178 healthcare staff was investigated. **Table 1** presents the baseline characteristics of the study population. The participants included 93 women (52.54%) and 84 men (47.46%). Of these, 101 individuals (56.74%) were aged 20-35 years. The mean and SD age value of the participants was 34.19±8.51 years (range: 22-65 years). The vast majority of them had the Bachelor of Science (BS) degrees (60.67%).

Overall, the average frequency of the sanitizers used during work shifts was 8 hours per staff. Of these, 92 individuals (51.68%) were allergic to sanitizers. Skin and breathing sensitivity were the most common symptoms in 44.38% and 27.68% of the health workers, respectively (**Figure 1**). Also, skin dryness (50%) and sore throat (25.84%) were the most common complications observed in skin and respiratory symptoms among health workers, respectively. According to the results, a significant difference was observed in the prevalence of the complications between the two genders (**Table 2**). No significant relationship was observed between the prevalence of the complications and other studied variables, such as age range and educational level (**Figure 2**).

**Table 3** presents the LDR (%) (v/v), calibration curve, R<sup>2</sup>, LOD, LOQ, and the mean recovery percentage of ethanol in gel, spray, and wash solution samples which were obtained in the range 89.25-93.89, 90.41-92.37, and 94.67-97.32%, respectively (**Table 3**). Some impurities were observed in two samples. Qualitative analysis showed that methanol and formic acid were observed in two spray samples. **Figure 3** shows the qualitative analysis of a hand sanitizer (spray) containing methanol.

**Table 2.** Relationship between gender and the complications of using hand sanitizers

Sensitivity	No. (%)		P
	Male	Female	
Skin	49(52.69)	29(34.52)	0.03
Breathing	14(16.67)	39(38.71)	0.09
Nervous	6(7.14)	14(15.05)	0.01
Gastrointestinal	0(0)	5(5.38)	0.01

Table 4 presents the mean and range of ethanol content in different sanitizer samples. The highest and the lowest percentages of ethanol found among the studied hand sanitizers were 68.24% and 60.71% which were attributed to washing solution and gel, respectively. The frequency of using gel, solution, and spray among them was 93.82%, 42.13%, and 49.44%, respectively. Some disinfectant and cleaning products are available that can effectively be used during the novel COVID-19 to clean hands and surfaces. With the prolongation of the COVID-19 pandemic, long-term use of disinfectants can cause many adverse effects among health workers. Alcohol-based hand sanitizers are commonly used in the hospital environment by health workers as a protective method during the novel COVID-19. The active reagents of alcohol-based hand sanitizers included ethanol or isopropyl alcohol with a concentration ranging from 60% to 95% [16]. Moreover, it has been recommended by the World Health Organization (WHO) to use ethanol, isopropyl alco-

hols, and hydrogen peroxides in the manufacture of alcohol-based hand sanitizers. In this regard, in the present study, the complications caused by the frequent use of disinfectants among health workers were investigated in Hamadan, and then to determine the quality of the disinfectant products used by health care workers, their components were determined.

The results show the sensitivity with a higher frequency among females, and this difference was significant in all studied symptoms. This difference can be attributed to their greater sensitivity and commitment to observing the principles of infection prevention in women. According to the results, the mean recovery percentage of ethanol in gel, spray and wash solution samples were obtained in the range of 69.21- 70.32, 59.22- 68.62, and 59.12-72.11%, respectively. Therefore, the ethanol content of the studied hand sanitizer products was in the appropriate range for the inactivation of viruses. In a review study, it has been reported

**Table 3.** Values of LDR, LOD, and LOQ for ethanol in gel spray and wash solutions

Sample	Range of Linearity (v/v)	Equation of Calibration Curve	R <sup>2</sup>	LOD (v/v)	LOQ (v/v)
Gel	5-100	Y=0.140 ± 0.008 X+0.8	99.01	0.11	0.35
Spray	5-100	Y=0.135 ± 0.005 X+0.2	99.84	0.08	0.26
Wash solution	5-100	Y=0.105 ± 0.001 X+0.6	99.33	0.06	0.21

Linear dynamic range (LDR), accuracy, calibration curve, Limits of Detection (LOD) and Limit of Quantification (LOQ)

**Table 4.** Mean recovery percentage for various levels of spiked ethanol in gel, spray, and washing solution

Hand Sanitizers	No	Ethanol Content	
		Mean±SD	Range
Gel	10	60.71± 8	69.21-70.32
Spray	11	66.73±10.7	59.22-68. 62
Wash solution	44	68.24±11.04	59.12-72.11

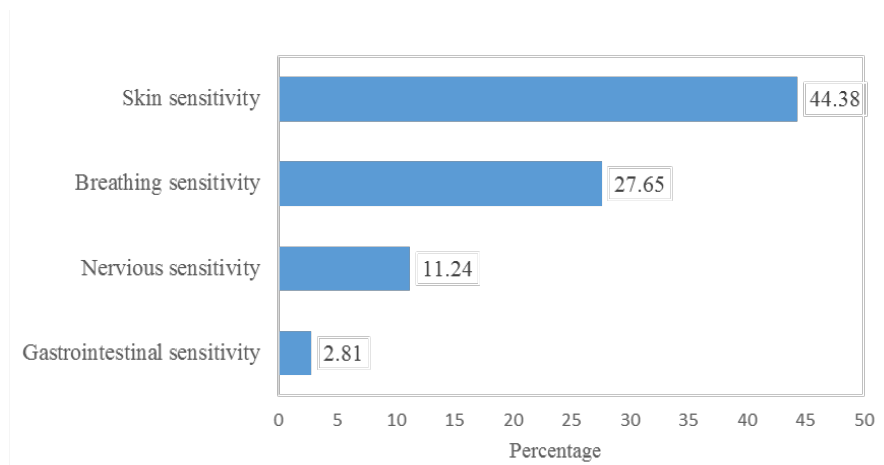


Figure 1. Percentage of common occurred sensitivity among hospital staff

that gel hand sanitizers containing 60% ethanol can effectively reduce viral load after 30 s [17], which is consistent with the value obtained for gel hand sanitizer in the present study. However, 70% ethanol has been selected as the reference alcohol to reduce and inactivate viruses [15].

The results implied that the highest and the lowest percentages of ethanol in the gel and spray among the studied hand sanitizer were in the range of 59.12%-72.11%,

respectively. The results demonstrated that the frequency of using gel, alcohol solution, and alcohol spray among the studied health care workers was 93.82%, 42.13%, and 49.44%, respectively. Skin sensitivity with a frequency of 44.3% was the most common complication observed in the studied health care personnel. This finding is consistent with the results of the previous studies [16]. Dermal contact with ethanol has been reported to be associated with irritation and allergic condition of skin and eyes, while prolonged exposure results in dryness or cracking

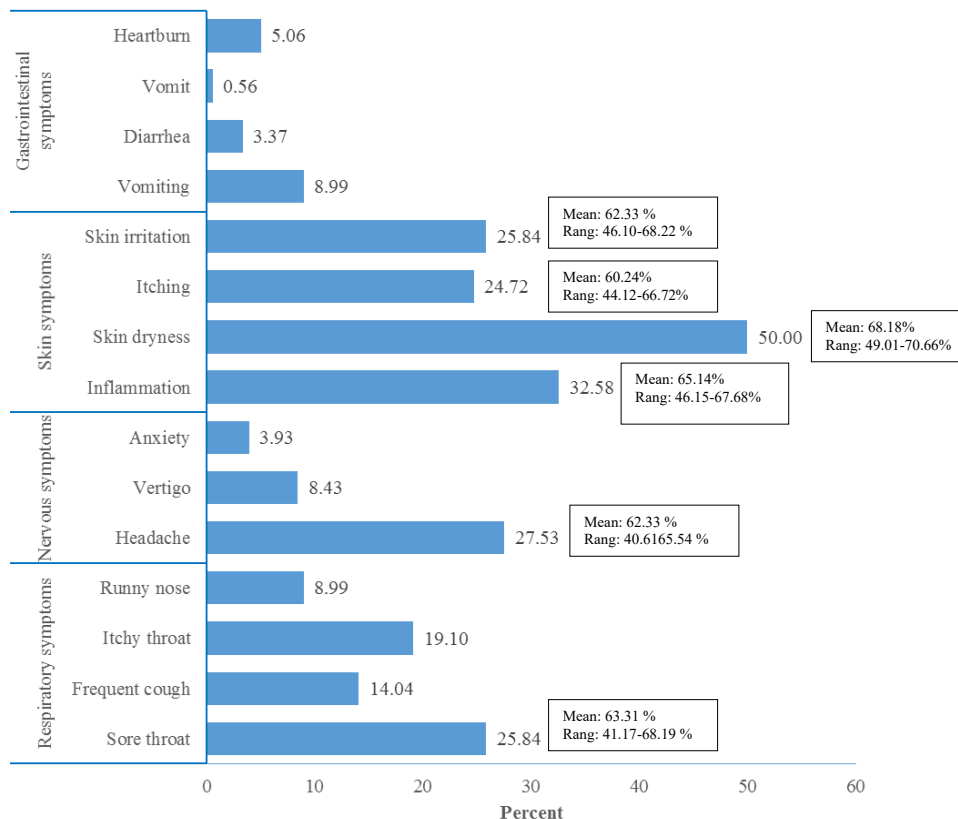
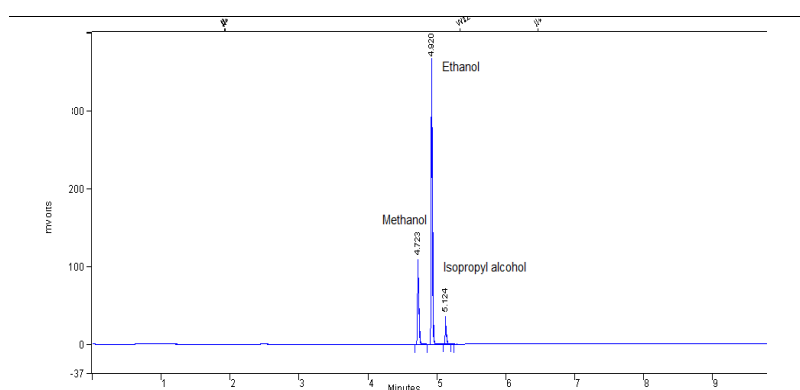


Figure 2. The percentage of side effects occurred of each symptom the relation with percentage mean of ethanol among hospital staffs.



**Figure 3.** Qualitative analysis of a hand sanitizer

of skin with peeling redness or itching [16]. Moreover, in a previous study, it has been reported that frequent use of ethanol is associated with skin irritation or contact dermatitis [18]. According to the results, 92 healthcare workers (51.68%) were allergic to disinfectants. Skin and breathing sensitivity were the most common sensitivity in 44.38% and 27.68% of the health care staff, respectively. As observed, nervous and gastrointestinal sensitivity was less common among the studied staff.

Among the skin symptoms, dryness was identified as the most common complication with a frequency of 50%. This complication is clearly due to the frequent use of hand sanitizers. However, long-term use of latex gloves and personal protective equipment can also play an aggravating role in skin symptoms among healthcare staff in the medical environment. All skin symptoms were observed with relatively high prevalence in the healthcare personnel. These results are consistent with the findings of a recent previous study, in which skin dryness was identified as the most common complication among health care staff [7]. This finding highlights the role of using appropriate alcohol-based hand rubs with suitable formulations in the hospital environment. Moreover, the [World Health Organization \(WHO\)](#) has recommended that the ethanol-based hand rub formulation contains 1.45% glycerol as an emollient to protect the skin of healthcare workers against dryness and dermatitis. Furthermore, a related study showed that 0.5% glycerol can offer better protective effects for the skin of healthcare workers against skin problems [19]. This point should be considered for the production of ethanol-based hand rubs in hospitals to reduce the adverse health effects caused by the long-term and extensive use of hand sanitizers among health workers. Moreover, our findings indicated that methanol and formic acid were observed in two spray samples. In addition to the toxic effects of these impurities, they can increase skin and respiratory complications for medical personnel.

## 4. Conclusion

This study was conducted to investigate various complications caused by the frequent use of alcohol-based hand rubs during the COVID-19 pandemic among health workers in Hamadan City, Iran. The results implied that the highest and the lowest percentages of ethanol were observed in the washing solution, and gel, respectively. The frequency of using gel, solution, and spray were 93.82%, 42.13%, and 49.44%, respectively. A total of 92 healthcare staff (51.68%) was allergic to the sanitizers. Skin and breathing sensitivity were the most common symptoms among health workers. Based on the results, skin dryness and sore throat were the most common complications in the skin and respiratory systems of the health workers. Our findings highlight the role of using appropriate alcohol-based hand rubs with suitable formulations in the hospital environment to reduce the adverse health effects caused by the long-term and extensive use of hand sanitizers among health workers. Moreover, identifying some unwanted compounds in the studied hand sanitizers emphasizes the importance of regular monitoring of the quality of these products.

## Ethical Considerations

### Compliance with ethical guidelines

The protocol of this study was approved by the Ethical Code of [Hamadan University of Medical Sciences](#) (Code: IR.UMSHA.REC.1399.234).

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### Authors' contributions

Conceptualization and Supervision: Ali Poormohammadi; Methodology: Saeid Bashirian; Investigation, Writing-original draft, and Writing-review & editing: All authors; Data collection: Salman Khazaee; Data analysis: Reza Solgi; Funding acquisition and Resources: Ali Reza Soltanian, Mohammadreza Sobhan, Fereshteh Mehri.

### Conflict of interest

The authors declare no conflict of interest.

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