Environmental Health Engineering and Management Journal. 2025;12:1277
http://ehemj.com
doi 10.34172/EHEM.1277
Environmental Health Engineering and Management Journal
Original Article
Open Access Publish Free

Systematic deep approach and the perseverance survey of COVID-19 virus on non-living surfaces and the efficacy of sanitizers in high-contact surfaces: A case study in the oil and gas capital city north shore of Persian Gulf, Iran

Nastaran Talepour[1,2], Mana Ghanbari[1,2], Niloofar Neisi[3,4], Yalda Hashempour[5], Amir Zahedi[6], Zeinab Ghaedrahmat[6], Amir Danyaei[7], Amal Saki Malehi[2], Neamatollah Jaafarzadeh[8*]

[1]Student Research Committee, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[2]Department of Environmental Health Engineering, Faculty of Public Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[3]Infectious and Tropical Diseases Research Center, Health Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[4]Department of Medical Virology, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[5]Department of Environmental Health Engineering, School of Public Health, Mazandaran University of Medical Sciences, Sari, Iran
[6]Department of Environmental Health Engineering, Shoushtar Faculty of Medical Sciences, Shoushtar, Iran
[7]Department of Medical Physics, The School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[8]Toxicology Research Center, Medical Basic Sciences Research Institute, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Abstract

Background: The ongoing COVID-19 pandemic has emphasized the significance of understanding the role of commonly contacted surfaces in the virus circulation. This study aimed to examine the contamination levels of the COVID-19 virus on repeatedly manipulated surfaces within urban areas.

Methods: We have conducted a study based on a systematic review and used it to choose a methodology, compare, and interpret the data. In this research, 22 samples were obtained from diverse surfaces in the environment, both before and after the implementation of sanitizer protocols.

Results: The results obtained from sampling and polymerase chain reaction (PCR) analysis conducted before sanitizers revealed that out of the 22 samples, 4 cases (18.18%) tested positive. However, none of the 22 samples showed any positive cases following the sanitizer process.

Conclusion: By conducting a comprehensive analysis, this research contributes to the existing body of knowledge regarding the effectiveness of sanitizer measures in mitigating the spread of the virus in urban environments.

Keywords: COVID-19, Polymerase chain reaction, COVID-19 testing, Disinfectants, Pandemics

Citation: Talepour N, Ghanbari M, Neisi N, Hashempour Y, Zahedi A, Ghaedrahmat Z, et al. Systematic deep approach and the perseverance survey of COVID-19 virus on non-living surfaces and the efficacy of sanitizers in high-contact surfaces: a case study in the oil and gas capital city north shore of Persian Gulf, Iran. Environmental Health Engineering and Management Journal. 2025;12: 1277. doi: 10.34172/EHEM.1277

Article History:
Received: 28 January 2024
Revised: 20 February 2024
Accepted: 4 March 2024
ePublished: 4 March 2025

***Correspondence to:**
Neamatollah Jaafarzadeh,
Email: n.jaafarzade@gmail.com

Introduction

Since late 2019, the global community has been grappling with unexpected and severe respiratory diseases caused by the type 2 coronavirus known as SARS-CoV-2. The death toll has tragically decreased by approximately 7 million (1-4). To prevent the spread of the virus, governments have implemented measures such as restrictions, physical distancing, and border closures (5). Due to the high speed of transmission of SARS-CoV-2 , the likelihood of acquiring COVID-19 is elevated in congested and inadequately ventilated settings where infected individuals spend extended durations close to one another (6,7). The transmission of the infection can occur through the release of small liquid particles from the mouth or nose of an infected individual, which can happen during actions like coughing, sneezing, talking, singing, or even breathing. These particles encompass a spectrum from larger respiratory droplets to smaller aerosols (8). COVID-19 has been shown to survive for extended periods on various dry surface materials such as plastic, metal, or glass, ranging from two hours to nine days, with a high transfer capacity (9,10). The virus is carried through the surroundings by tiny droplets, acting as agents for transmission. Multiple studies have highlighted how environmental factors, including temperature, humidity, wind velocity, and air quality, can impact the likelihood of a viral outbreak to varying degrees (11-16). Subsequently, numerous investigations have been carried out to evaluate the survival of SARS-CoV-2 on surfaces and the effectiveness of chemical disinfectants against SARS-CoV-2 on frequently touched surfaces (15,17-19). Gidari et al. investigated the survival of SARS-CoV-2 on various surfaces and the efficacy of UV-C light in reducing viral load. They discovered that the virus remained contagious on plastic and glass surfaces for 120 hours, and on stainless steel, it endured for 72 hours. Moreover, UV-C irradiation exhibited remarkable effectiveness, decreasing the viral titer by 99.99% (20). Hardison et al conducted a study investigating the efficacy of chemical disinfectants against SARS-CoV-2 on surfaces commonly touched by people. Their findings emphasized that the effectiveness of disinfectants varied based on factors such as the surface type, the specific disinfectant utilized, and the disinfection method employed (21). Therefore, identifying contamination on public surfaces is crucial. With significant population density and heavy foot traffic on pavements, Ahvaz has been identified as a key city affected by the coronavirus. This study aimed to investigate the transmission of the virus from frequently visited and heavily touched surfaces in Ahvaz city. The goal was to identify the existence of SARS-CoV-2 on a range of surfaces within urban environments that people encounter regularly amid the COVID-19 pandemic. The findings of this cross-sectional study would facilitate the development and implementation of guidelines and scientific protocols for effective cleaning and sanitizers of surfaces.

Materials and Methods

This study unfolded in two key phases: a comprehensive systematic review and subsequent experimental inquiry (22).

Literature sources and search strategy

We utilized prominent electronic databases, including Web of Science, Scopus, and PubMed, to find research articles from 2020 to 2023. The main aim of these articles was to assess the persistence of the COVID-19 virus on inanimate surfaces and evaluate sanitizer efficacy on frequently touched surfaces. We employed the subsequent search approach within the database.

- PubMed: (“COVID-19” OR “SARS-CoV-2”) AND (“surface transmission” OR “fomite transmission”) AND (“sanitizer” OR “disinfectant”)
- Web of Science: TS=(“COVID-19” OR “SARS-CoV-2”) AND TS=(“fomite transmission” OR “sanitizer efficacy”)
- Scopus: TITLE-ABS-KEY (“COVID-19” OR “SARS-CoV-2”) AND TITLE-ABS-KEY (“fomite transmission” OR “sanitizer efficacy”)

In the screening phase, we systematically removed duplicate records and irrelevant articles by thoroughly reviewing titles, abstracts, and keywords. Articles that were not in English, lacked full text, or took the form of letters, corrections, notes, and conference materials were excluded. Following this, a careful selection process identified pertinent articles for in-depth examination. Notably, 11 papers were found to focus specifically on studying the persistence of the COVID-19 virus on inanimate surfaces and evaluating sanitizer efficacy on frequently touched surfaces. The entire literature search process is visually presented in Figure 1.

Study area

The study area for this cross-sectional investigation was Ahvaz, situated in the southwest region of Iran and serving as the central hub of Khuzestan province. With a population of 1 425 891, Ahvaz is known for its high population density and industrial significance. The city boasts a warm and humid climate, along with a substantial concentration of specialized hospitals, making it a prominent healthcare center for Khuzestan. The geographical layout and sampling points of the study area are visually depicted in Figure 2. We used the STROBE cross-sectional reporting guidelines (23).

In the study’s planning, we thoughtfully selected the main public spaces in the city characterized by significant pedestrian activity and congestion. Throughout sample collection from October 2 to 25, 2021, we collected a total of 22 samples from diverse environmental surfaces. During this period, temperatures fluctuated between 32 °C and 35 °C, and the average humidity levels spanned from 35% to 50%.

Surface sampling

Skilled workers, who had undergone biosecurity coaching

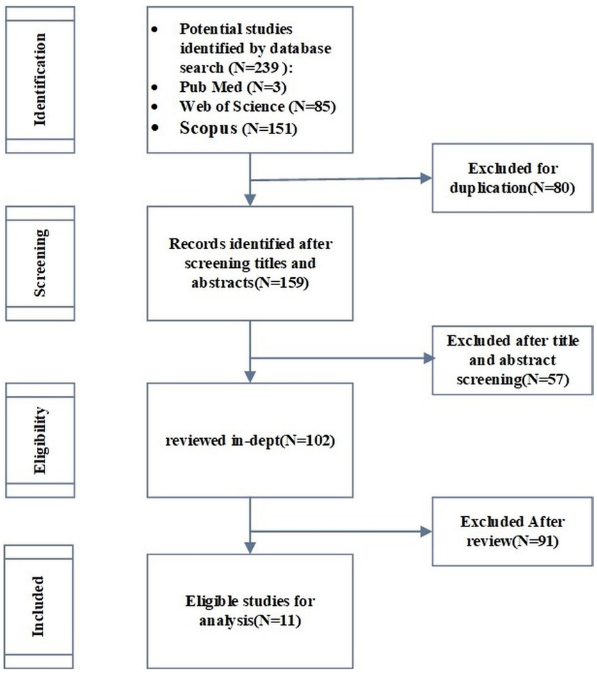

Figure 1. Flow chart of literature search

Figure 2. The study area and sampling points

and were endowed with individual safeguarding, gathered the environmental samples. In this study, a total of 22 swab samples were collected from high-traffic locations in Ahvaz before any sanitizer procedures took place. Samples were collected from various surfaces across the city, encompassing locations such as escalators in shopping malls, doors within malls, seats in malls, ATMs found in supermarkets and bakeries, door handles of taxis, bank entrances, and glass surfaces in pharmacies. The sampling procedure adhered to the guidelines set forth by the World Health Organization (WHO) (24,25). Surface samples were acquired using a swab, with careful consideration given to maintaining sterile conditions. The swab was removed from its packaging and moistened with a viral transport medium. Subsequently, an area measuring 10 cm^2 was swabbed by applying adequate pressure to the surface and rotating the swab stick for 30 seconds. The swab was then placed into falcon tubes, which were completely sterile and contained Dulbecco's modified eagle medium (DMEM). These Falcon tubes were securely stored in a seamless bag. To improve results and enhance the accuracy of sampling, three swabs were utilized for each surface. These three swabs, associated with a single surface, were then placed together inside a falcon tube that contained the culture medium. Before being placed in the transport container, the seamless bag underwent cleaning using a 70% ethanol solution. Samples used as controls were acquired using an identical process to that employed for environmental samples collected from areas at risk of contamination. This process entailed opening the package and extracting the swab from the tube, but without conducting any actual surface sampling (26). The collected samples were conveyed to the laboratory in a cool box, maintaining a temperature of approximately 4 °C (27). The collected samples encompassed various materials such as metal, plastic, and glass. Additionally, the stage of gathering and the prevailing weather parameters were recorded during the sampling process. All samples were transferred to the laboratory with a cool box within a temperature range of around 4 °C (28).

Laboratory analysis

The viral genome was purified using the Sina Pure Viral kit (Sinaclon, Iran) for nucleic acid extraction and stored in a deep freezer at -70 °C. The purity of the extracted RNAs was assessed using a Nanodrop (Thermo Scientific, USA). To confirm the presence of the virus, a real-time reverse transcription-polymerase chain reaction (RT-PCR) was performed in the laboratory. Adhering to the instructions provided by the Pishtaz Teb Zaman kit in Iran, 5 µL of extracted RNA was combined with 15 µL of One-Step qRT-PCR master mix, which included primers and TaqMan probes tailored for the RdRp and N genes. The amplification and subsequent analysis were executed using the RT-PCR system, specifically on the Applied Biosystems StepOnePlus platform. The thermal cycling process comprised an initial reverse transcription at 50 °C for 20 minutes, followed by an initial denaturation step at 95 °C for 3 minutes. Subsequently, there were 45 cycles involving heating at 94°C for 10 seconds and cooling at

55 °C for 40 seconds. Samples exhibiting cycle threshold (Ct) values below 40 cycles were classified as positive. In instances where Ct values ranged from 40 to 45 cycles, the PCR procedure was reiterated. Every experiment integrated negative controls to pinpoint potential contamination and positive controls were incorporated to uncover any potential false-negative samples (29,30).

Results

The objective of this study was to examine how long SARS-CoV-2 can survive on non-living surfaces and the effectiveness of disinfectants on high-contact surfaces in Ahvaz, a densely populated and industrial city. The findings from the systematic review, outlined in Table 1, were employed for selecting a methodology, conducting comparisons, and interpreting the data. Based on the review findings, the samples were collected from frequently touched surfaces in densely populated areas of Ahvaz. SARS-CoV-2 RNA was discovered on a variety of surfaces at various sampling points. The environmental conditions and the outcomes of real-time reverse transcription polymerase chain reaction (RT-PCR) for different sites within Ahvaz City's surface samples before sanitizers are presented in Table 2. The contaminated environmental surfaces in different locations included escalators in malls, mall doors, mall seats, ATMs in supermarkets and bakeries, taxi door handles, bank doors, metal fences at bank entrances, and glass surfaces in pharmacies. The results of the sampling and PCR conducted before sanitizers revealed that out of the total 22 samples, 4 cases (18.18%) tested positive. During the sampling period, the temperature ranged from 32 to 35 °C, while the relative humidity (RH%) varied between 35% and 50%, respectively. Table 3 displays the laboratory test outcomes following the sanitizer process. After the sanitizers, none of the 22 samples tested positive.

Discussion

Extensive research has consistently supported the notion that viruses tend to settle more rapidly under low temperatures and high humidity conditions. They can spread as droplets or aerosols, with larger particle sizes being retained and quickly settling due to the increased weight caused by higher humidity. These particles can also be hindered by factors like masks and the nasal cavity. Additionally, it is worth noting that higher temperatures and humidity levels can contribute to enhancing human immunity (38,39). Multiple empirical investigations have provided validation for the potential presence of live SARS-CoV-2 on environmental surfaces subjected to frequent contact, with the viability affected by variables like the kind of surface material and environmental conditions (40). The longevity of SARS-CoV-2 on surfaces surpasses that of other coronaviruses (41). Van Doremalen et al conducted a study comparing the aerosol and surface stability of SARS-CoV-2 to that of SARS-CoV-1. Their findings revealed that, under the specific experimental conditions tested, the stability of SARS-CoV-2 was similar to that of SARS-CoV-1. This implies that variations in the epidemiological characteristics of these viruses likely stem from other factors, such as high viral loads in the upper respiratory tract and the potential for asymptomatic individuals infected with SARS-CoV-2 to shed and transmit the virus. The study results suggest the plausibility of SARS-CoV-2 transmission through aerosols and contaminated surfaces, as the virus can remain viable and infectious in aerosols for several hours and on surfaces for several days, depending on the amount of viral material shed (42). Gavaldà-Mestre et al conducted a study on the contamination of high-touch surfaces in public areas adjacent to COVID-19 hospitalization units, focusing on the presence of SARS-CoV-2 and bacterial loads. They gathered a combined total of 92 samples from 46 different high-contact surfaces. Despite the high bacterial loads indicating frequent contact with the surfaces before sampling, no presence of SARS-CoV-2 was detected at any of the sites. These findings indicate that compliance with infection prevention practices COVID-19 patients was appropriate, especially using the masking and hand hygiene surface disinfection in controlling the contamination of high contact surfaces with the SARS-CoV-2 virus adherence (43). Harvey et al researched to monitor the occurrence of SARS-CoV-2 RNA on frequently touched surfaces in a community setting across a duration. Their findings revealed that while SARS-CoV-2 RNA was detected on only 8.3% of the surfaces tested, more than 50% of all surfaces showed positive results at least once during the study period. According to the authors, these findings suggest that monitoring a single surface or a few surfaces alone would not be sufficient for effective environmental surveillance of SARS-CoV-2 at the community level. They recommended that broader sampling across multiple locations is necessary to accurately capture the true patterns of COVID-19 cases (44). The results of the present study, aligned with previous studies, show that in the areas where health and protection practices have been implemented, the presence of the SARS-CoV-2 virus was less or not observed. Hennessy et al. investigated the contamination of high-touch surfaces in public areas by COVID-19. According to their findings, out of 210 surfaces tested, 3 (1.4%) were found to be positive for SARS-CoV-2 viral RNA. Specifically, two (2.3%) of the positive surfaces were traffic light buttons, and one (1.8%) was a handle on a playground swing. The authors underscored the likelihood of viruses contaminating frequently touched surfaces in public spaces, emphasizing the role these contaminated surfaces can play in facilitating the ongoing transmission of infections (45). Traffic light buttons and handle playground swings are less disinfected and these surfaces

Table 1. The relevant papers discussing the perseverance survey of COVID-19 virus on non-living surfaces and the efficacy of sanitizers in high-contact surfaces

Title	Location	Year	Key Findings	Reference
Efficacy of chemical disinfectants against SARS-CoV-2 on high-touch surface materials	USA	2023	• The efficacy of disinfectants relied on the type of surface, the specific disinfectant used, and the disinfection process. • Using mechanical wiping alone proved somewhat effective in eliminating SARS-CoV-2 from surfaces • Detecting viral RNA post-disinfection could potentially result in an overestimation of the remaining infectious virus.	(21)
SARS-CoV-2 survival on surfaces and the effect of UV-C light	Italy	2021	• SARS-CoV-2 remained infectious on plastic and glass surfaces for 120 hours and on stainless steel for 72 hours. • UV-C irradiation proved highly effective, reducing the virus titer by 99.99%, with lower doses being particularly successful on glass surfaces.	(20)
Potential role of inanimate surfaces for the spread of coronaviruses and their inactivation with disinfectant agents	Germany	2020	• Exploring potential pathways for human-to-human transmission, assessing the effectiveness of specific disinfectants, and emphasizing the importance of surface disinfection to control and prevent the virus's spread.	(19)
Efficacy of detergent-based cleaning and wiping against SARS-CoV-2 on high-touch surfaces	USA	2023	• Wiping surfaces with hard water effectively reduced SARS-CoV-2, and the added step of surface pre-wetting did not consistently improve efficacy. • Cleaning porous surfaces showed minimal effectiveness, highlighting distilled water (DW) as the most efficient method for reducing SARS-CoV-2 on certain surfaces.	(31)
SARS-CoV-2 viability on 16 common indoor surface Finish materials	USA	2021	• Within 12 hours post-infection, infectious SARS-CoV-2 was recoverable from only four surfaces. • By the 30-hour mark, it could only be retrieved from one surface. • Despite limited recoverable amounts over time, there is still a risk of viral transmission through surface contamination indoors. • It is crucial for individuals and institutions to adhere to proper decontamination protocols for indoor environments. • Increased vigilance regarding hand hygiene and the use of personal protective equipment is recommended.	(32)
Stability and infectivity of coronaviruses in inanimate environments	China	2020	• Coronaviruses, including SARS-CoV-2, can survive on surfaces for up to one month, implying the potential for surface transmission. • The risk of transmission through contaminated paper is low. • Respiratory and fecal specimens can maintain infectivity for an extended period at room temperature. • In inadequately ventilated buses, SARS-CoV-2 may linger in the air for at least 30 minutes, highlighting the potential for airborne transmission in specific environments.	(33)
Simulated sunlight rapidly inactivates SARS-CoV-2 on surfaces	USA	2020	• Sunlight rapidly deactivates SARS-CoV-2 on surfaces. • There is a significant difference in virus persistence between indoor and outdoor environments. • The rate of inactivation depends on the intensity of sunlight and the suspension medium.	(34)
Investigation of SARS CoV-2 virus in environmental surface	Iran	2021	• SARS-CoV-2 RNA was found in 9 out of 50 environmental surface samples. • This discovery indicates contamination on various surfaces within the hospital environment.	(35)
Contact transmission of SARS-CoV-2 on fomite surfaces: surface survival and risk reduction	India	2021	• Summarizing risk factors linked to indirect transmission of SARS-CoV-2 on fomite surfaces. • Emphasizing the primary mode of indirect transmission. • Focusing on methods to design advanced and effective antiviral surfaces.	(36)
Increasing temperature and relative humidity accelerates inactivation of SARS-CoV-2 on surfaces	China	2020	• SARS-CoV-2 decayed faster with higher humidity or temperature, unaffected by droplet volume or surface type. • The virus's half-life at room temperature (24°C) ranged from 6.3 to 18.6 hours, depending on relative humidity. • At 35°C, the half-life decreased to 1.0 to 8.9 hours. • Increased temperature and/or humidity led to a shorter duration of SARS-CoV-2 infectivity on hard, nonporous surfaces. • Persistence and exposure risk may vary significantly based on environmental conditions.	(37)
Survival and disinfection of SARS-CoV-2 in environment and contaminated surface	Malaysia	2020	• Detection of SARS-CoV-2 in sewage and water sources. • Requirement for frequent disinfection of indoor and outdoor surfaces. • Exploration of biosynthesis of nanoparticles as an alternative to conventional chemical and physical synthesis methods.	(17)

can be infected during frequent contact, which is consistent with the results of our study. The results of the present study show that some surfaces such as the payment machine and supermarkets and bakeries ATMs are the surfaces that are less cleaned and disinfected, so the level of contamination of the surfaces in them is high. In an independent investigation, Abrahão et al explored the existence of SARS-CoV-2 RNA on surfaces accessible to

Table 2. Environmental conditions and real-time reverse transcription polymerase chain reaction (RT-PCR) results of different sites of Ahvaz city's surface samples before sanitizers

Sampling Sites	Temperature (°C)	Humidity (%)	Number of Samples	Result	
				Negative	Positive
Mall escalator	33	35	1	1	0
Pharmacy glass	32	35	8	6	2
Metal fences at the entryways to banks	33	38	2	2	0
ATMs in supermarkets and bakeries	34	35	3	2	1
Taxi door handles	33	38	2	2	0
Bank doors	32	37	1	1	0
ATM	34	38	3	2	1
Mall seats	33	35	2	2	0

Table 3. Real-time reverse transcription polymerase chain reaction (RT-PCR) results of different sites of Ahvaz City's surface samples after sanitizers

Sampling Sites	Number of Samples	Result
Mall escalator	3	Negative
Pharmacy glass	4	Negative
Metal fences at the entryways to banks	3	Negative
ATMs in supermarkets and bakeries	2	Negative
Taxi door handles	4	Negative
Bank doors	2	Negative
ATM	2	Negative
Mall seats	2	Negative

the general public within a densely populated urban region in Brazil. Their findings indicated that, among 933 samples examined, 49 (5.25%) samples tested positive for SARS-CoV-2 RNA. These positive samples were obtained from various materials, including metal and concrete, and were located in diverse areas, with a notable presence around hospital care facilities and public squares (1). Montagna et al. examined the occurrence of SARS-CoV-2 on surfaces within 20 tourist and recreational venues. They collected 100 swab samples from diverse surfaces, encompassing handles of refrigerators, handrails, countertops, tables, and entrances to restrooms. The outcomes indicated that six swabs (6%) collected from four venues (20%) tested positive for SARS-CoV-2. These tainted surfaces encompassed handles on restroom doors, refrigerator handles, handrails, and bar countertops (46). The results of our study are consistent with the results of the previous study, and the concentration of viruses has been observed on metal surfaces such as payment machines and supermarkets and bakeries ATMs as a metal surface. Da Silva et al conducted a study focusing on the presence of SARS-CoV-2 on frequently touched surfaces within a major Brazilian city. In February 2021, they amassed 400 surface samples within Recife. The results revealed that 97 of these samples (24.2%) tested positive for SARS-CoV-2. Nearly all sampling locations, with just one exception (94.7%), displayed at least one contaminated environmental surface sample. The most prominent occurrences of SARS-CoV-2 were identified in transportation hubs (55.9%), followed by medical facilities (30.9%), beach areas (19.0%), public parks (13.3%), distribution centers (9.5%), and public markets (4.7%). Notably, surfaces like restrooms, ATMs, handrails, playgrounds, and outdoor fitness equipment exhibited the highest rates of SARS-CoV-2 presence (47). The present study showed that SARS-CoV-2 is positive on surfaces such as payment machines and medical centers, but unlike the study of da Silva et al, no positive cases were observed in shopping centers, transportation systems, and taxi surfaces. Di Carlo et al. conducted a study to investigate the existence of SARS-CoV-2 in the air and on surfaces within a bus operating under normal conditions. They took measurements during the final week of a lockdown and the following week as travel restrictions were eased. Throughout these two weeks, with over 1100 passengers using the bus, neither the virus nor its traces were discovered, whether in the air or on surfaces. These results suggest that the preventative measures enforced in public transportation are successful in curbing the transmission of COVID-19 (48). Noorimotlagh et al employed molecular techniques to detect SARS-CoV-2 RNA, revealing that the virus is most prominently present in healthcare facilities and hospital environments. Additionally, public areas with high-touch surfaces, such as Bank ATMs and POS machines, can serve as significant sources and avenues for COVID-19 transmission. Furthermore, SARS-CoV-2 exhibits a remarkable survival period of up to 28 days on various lifeless surfaces, with the exact duration influenced by environmental factors like temperature, light, and humidity. This extended survival time positions it as a more formidable link in the disease chain compared to other coronaviruses like SARS-CoV-1 and MERS-CoV. These findings align entirely with prior research, affirming their validity (49). Recognizing that the efficacy of sanitizer measures depends on several factors, including cleaning frequency, choice of disinfectant, and individual compliance with hygiene practices, is crucial. In the sanitation guidelines, it is crucial to take into account environmental variables like temperature and humidity. These factors have the potential to affect both the persistence and spread of the virus. The results of this study indicated significant differences in contamination levels of high-touch surfaces before and after sanitizers. Before sanitizers, a notable number of sampled surfaces showed detectable levels of SARS-CoV-2, indicating the potential for viral transmission. Viana Martins et al. indicated that the chemical agents and especially alcohols with concentrations of 60% reduction in viral titers. This showed that the Alcoholic agents are better cases to fast-acting and effective agents to SARS-CoV-2 inactivity. In the present study, alcohol was used to disinfect surfaces (50). However, following the implementation of sanitizers protocols, there was no presence of the virus, suggesting the effectiveness of these measures in reducing contamination. The reduction in SARS-CoV-2 presence on frequently touched surfaces following sanitization can be credited to a dual impact: the physical removal of the virus through cleaning and the chemical inactivation of any remaining viral particles. These results emphasize the significance of consistent and comprehensive sanitation measures in public areas, especially within densely populated urban regions. To sum it up, this investigation concerning high-contact surfaces in urban settings underscores the critical role of surface cleanliness in the fight against COVID-19 transmission. The outcomes of studies (Table 1) unequivocally show that systematic and meticulous sanitation procedures notably decrease the virus's presence on commonly touched surfaces. By implementing effective sanitizers measures, cities can greatly reduce the risk of transmission and create safer environments for their residents. However, it is important to emphasize that maintaining these practices is essential for long-term protection against the virus. Continued vigilance and adherence to proper cleaning and sanitizers procedures are vital to safeguard public health and prevent future outbreaks. These results add to the increasing wealth of proof advocating for the significance of surface cleanliness in halting transmission, emphasizing the continuous requirement for maintaining appropriate sanitation procedures in urban environments.

Conclusion

This study carried out in Ahvaz, Iran, offers valuable insights into the contamination levels of the COVID-19 virus on frequently touched surfaces and the effectiveness of sanitizers in reducing its presence. Our findings make a significant contribution to the current understanding of how sanitizers can help mitigate the spread of the virus on inanimate surfaces in urban settings. The study underscores the pivotal role of systematic and comprehensive sanitation procedures in mitigating the risk of viral transmission, especially in densely populated areas. The results also emphasize the dual impact of sanitization measures, encompassing both the physical removal and chemical inactivation of viral particles. The use of alcohol as a disinfectant agent aligns with previous research, underscoring its efficacy in reducing viral titers. This research not only augments the growing body of evidence supporting the role of surface cleanliness in impeding transmission but also underscores the persistent need for maintaining appropriate sanitization procedures in urban environments. Nevertheless, examining the resilience of COVID-19 and the effectiveness of sanitizers on inanimate surfaces encountered various limitations in this study. Primarily, our sample size was restricted, possibly not capturing the full range and intricacy of surfaces found in urban settings. Additionally, although no instances of transmission were identified after sanitizer application, it is essential to recognize that the efficacy of sanitizer protocols could vary based on factors like application method, frequency, and the type of sanitizer used. Further research is warranted to evaluate the enduring efficiency and longevity of these measures in combatting the protracted pandemic and potential outbreaks of contagious illnesses.

Acknowledgments

The authors wish to thank the Toxicology Research Center of Ahvaz Jundishapur University (Grant No. TRC-9915).

Authors' contributions

Conceptualization: Nematollah Jaafarzadeh.
Data curation: Nastaran Talepour, Mana Ghanbari.
Formal analysis: Amir Danyaei, Nastaran Talepour.
Funding acquisition: Nematollah Jaafarzadeh.
Investigation: Mana Ghanbari, Niloofar Neisi.
Methodology: Niloofar Neisi, Nematollah Jaafarzadeh.
Project administration: Nematollah Jaafarzadeh.
Resources: Amir Zahedi, Zeinab Ghaedrahmat.
Software: Nastaran Talepour, Mana Ghanbari, Amal Saki Malehi.
Supervision: Nematollah Jaafarzadeh.
Validation: Nematollah Jaafarzadeh.
Visualization: Nastaran Talepour.
Writing–original draft: Nastaran Talepour.
Writing–review & editing: Yalda Hashempour, Nematollah Jaafarzadeh.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical issues

The authors hereby certify that all data collected in the field of study were described in the manuscript and no data from the study have been or will be published separately elsewhere (Approval code: 122, Ethical code: IR.AJUMS.REC.1399.620).

Funding

Funded by the Toxicology Research Center of Ahvaz Jundishapur University (Grant No. TRC-9915).

References

1. Abrahão JS, Sacchetto L, Rezende IM, Rodrigues RA, Crispim AP, Moura C, et al. Detection of SARS-CoV-2 RNA on public surfaces in a densely populated urban area of Brazil: a potential tool for monitoring the circulation of infected patients. Sci Total Environ. 2021;766:142645. doi: 10.1016/j.scitotenv.2020.142645.
2. Cheng P, Luo K, Xiao S, Yang H, Hang J, Ou C, et al. Predominant airborne transmission and insignificant fomite transmission of SARS-CoV-2 in a two-bus COVID-19 outbreak originating from the same pre-symptomatic index case. J Hazard Mater. 2022;425:128051. doi: 10.1016/j.jhazmat.2021.128051.
3. Worldometer. Coronavirus. 2021. Available from: https://www.worldometers.info.
4. Mosaferi M, Gilani N, Delfi S, Ahmadpour R, Kumar Chattu V. Psychometric development and practical use of questionnaires designed to assess knowledge, attitude, and practice of women regarding the use of sanitizer at home to control coronavirus disease. Environ Health Eng Manag. 2022;9(1):55-64. doi: 10.34172/ehem.2022.07.
5. Abduljabbar RL, Liyanage S, Dia H. A systematic review of the impacts of the coronavirus crisis on urban transport: key lessons learned and prospects for future cities. Cities. 2022;127:103770. doi: 10.1016/j.cities.2022.103770.
6. Brote de Enfermedad Por Coronavirus (COVID-19): Orientaciones Para el Público. 2022. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.
7. Luo K, Lei Z, Hai Z, Xiao S, Rui J, Yang H, et al. Transmission of SARS-CoV-2 in public transportation vehicles: a case study in Hunan province, China. Open Forum Infect Dis. 2020;7(10):ofaa430. doi: 10.1093/ofid/ofaa430.
8. World Health Organization (WHO). Coronavirus Disease (COVID-19). 2021. Available from: https://www.who.int/health-topics/coronavirus#tab=tab_1.
9. Karani R, Zeng Q, Abdelhakim A, Diaconita V, Moussa O, Zhou HW, et al. Analysis of SARS-CoV-2 RNA on surfaces in New York City. J Glob Health. 2021;11:05022. doi: 10.7189/jogh.11.05022.
10. Christian M, Wibowo S, Yulita H, Melati R, Sunarno S, Titis Perdini F. Two phases of online food delivery app users' behavior in Greater Jakarta during the second year of the COVID-19 pandemic: perceptions of food safety and hygiene. Environ Health Eng Manag. 2023;10(3):249-59. doi: 10.34172/ehem.2023.28.
11. Xu X, Zhang J, Zhu L, Huang Q. Transmission of SARS-CoV-2 indoor and outdoor environments. Atmosphere. 2021;12(12):1640. doi: 10.3390/atmos12121640.
12. Moriyama M, Ichinohe T. High ambient temperature dampens adaptive immune responses to influenza A virus infection. Proc Natl Acad Sci U S A. 2019;116(8):3118-25. doi: 10.1073/pnas.1815029116.
13. Shaman J, Pitzer VE, Viboud C, Grenfell BT, Lipsitch M. Absolute humidity and the seasonal onset of influenza in the continental United States. PLoS Biol. 2010;8(2):e1000316. doi: 10.1371/journal.pbio.1000316.
14. Kudo E, Song E, Yockey LJ, Rakib T, Wong PW, Homer RJ, et al. Low ambient humidity impairs barrier function and innate resistance against influenza infection. Proc Natl Acad Sci U S A. 2019;116(22):10905-10. doi: 10.1073/pnas.1902840116.
15. Otter JA, Donskey C, Yezli S, Douthwaite S, Goldenberg SD, Weber DJ. Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination. J Hosp Infect. 2016;92(3):235-50. doi: 10.1016/j.jhin.2015.08.027.
16. Shaman J, Kohn M. Absolute humidity modulates influenza survival, transmission, and seasonality. Proc Natl Acad Sci U S A. 2009;106(9):3243-8. doi: 10.1073/pnas.0806852106.
17. Al-Gheethi A, Noman E, Al-Maqtari Q, Almoheer R, Radin M, Hamdan R. Survival and Disinfection of SARS-CoV-2 in Environment and Contaminated Surface. Preprints. 2020. Available from: https://www.preprints.org/manuscript/202006.0259/v1.
18. Bedrosian N, Mitchell E, Rohm E, Rothe M, Kelly C, String G, et al. A systematic review of surface contamination, stability, and disinfection data on SARS-CoV-2 (through July 10, 2020). Environ Sci Technol. 2021;55(7):4162-73. doi: 10.1021/acs.est.0c05651.
19. Kampf G. Potential role of inanimate surfaces for the spread of coronaviruses and their inactivation with disinfectant agents. Infect Prev Pract. 2020;2(2):100044. doi: 10.1016/j.infpip.2020.100044.
20. Gidari A, Sabbatini S, Bastianelli S, Pierucci S, Busti C, Bartolini D, et al. SARS-CoV-2 survival on surfaces and the effect of UV-C light. Viruses. 2021;13(3):408. doi: 10.3390/v13030408.
21. Hardison RL, Nelson SW, Limmer R, Marx J, Taylor BM, James RR, et al. Efficacy of chemical disinfectants against SARS-CoV-2 on high-touch surface materials. J Appl Microbiol. 2023;134(1):lxac020. doi: 10.1093/jambio/lxac020.
22. Azizi N, Pirsaheb M, Jaafarzadeh N, Nabizadeh Nodehi R. Microplastics removal from aquatic environment by coagulation: selecting the best coagulant based on variables determined from a systematic review. Heliyon. 2023;9(5):e15664. doi: 10.1016/j.heliyon.2023.e15664.
23. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7. doi: 10.1016/s0140-6736(07)61602-x.
24. World Health Organization (WHO). Surface Sampling of Coronavirus Disease (COVID-19): A Practical "How to" Protocol for Health Care and Public Health Professionals, 18 February 2020. WHO; 2020.
25. Minich JJ, Ali F, Marotz C, Belda-Ferre P, Chiang L, Shaffer JP, et al. Feasibility of using alternative swabs and storage solutions for paired SARS-CoV-2 detection and microbiome analysis in the hospital environment. Microbiome. 2021;9(1):25. doi: 10.1186/s40168-020-00960-4.
26. Mouchtouri VA, Koureas M, Kyritsi M, Vontas A, Kourentis L, Sapounas S, et al. Environmental contamination of SARS-CoV-2 on surfaces, air-conditioner and ventilation systems. Int J Hyg Environ Health. 2020;230:113599. doi: 10.1016/j.ijheh.2020.113599.

27. Razzini K, Castrica M, Menchetti L, Maggi L, Negroni L, Orfeo NV, et al. SARS-CoV-2 RNA detection in the air and on surfaces in the COVID-19 ward of a hospital in Milan, Italy. Sci Total Environ. 2020;742:140540. doi: 10.1016/j.scitotenv.2020.140540.
28. Moreno T, Pintó RM, Bosch A, Moreno N, Alastuey A, Minguillón MC, et al. Tracing surface and airborne SARS-CoV-2 RNA inside public buses and subway trains. Environ Int. 2021;147:106326. doi: 10.1016/j.envint.2020.106326.
29. Seif F, Noorimotlagh Z, Mirzaee SA, Kalantar M, Barati B, Emamian Fard M, et al. The SARS-CoV-2 (COVID-19) pandemic in hospital: an insight into environmental surfaces contamination, disinfectants' efficiency, and estimation of plastic waste production. Environ Res. 2021;202:111809. doi: 10.1016/j.envres.2021.111809.
30. Lei H, Ye F, Liu X, Huang Z, Ling S, Jiang Z, et al. SARS-CoV-2 environmental contamination associated with persistently infected COVID-19 patients. Influenza Other Respir Viruses. 2020;14(6):688-99. doi: 10.1111/irv.12783.
31. Nelson SW, Hardison RL, Limmer R, Marx J, Taylor BM, James RR, et al. Efficacy of detergent-based cleaning and wiping against SARS-CoV-2 on high-touch surfaces. Lett Appl Microbiol. 2023;76(3):ovad033. doi: 10.1093/lambio/ovad033.
32. Ronca SE, Sturdivant RX, Barr KL, Harris D. SARS-CoV-2 viability on 16 common indoor surface finish materials. HERD. 2021;14(3):49-64. doi: 10.1177/1937586721991535.
33. Ren SY, Wang WB, Hao YG, Zhang HR, Wang ZC, Chen YL, et al. Stability and infectivity of coronaviruses in inanimate environments. World J Clin Cases. 2020;8(8):1391-9. doi: 10.12998/wjcc.v8.i8.1391.
34. Ratnesar-Shumate S, Williams G, Green B, Krause M, Holland B, Wood S, et al. Simulated sunlight rapidly inactivates SARS-CoV-2 on surfaces. J Infect Dis. 2020;222(2):214-22. doi: 10.1093/infdis/jiaa274.
35. Dargahi A, Jeddi F, Vosoughi M, Karami C, Hadisi A, Ahamad Mokhtari S, et al. Investigation of SARS CoV-2 virus in environmental surface. Environ Res. 2021;195:110765. doi: 10.1016/j.envres.2021.110765.
36. Tharayil A, Rajakumari R, Mozetic M, Primc G, Thomas S. Contact transmission of SARS-CoV-2 on fomite surfaces: surface survival and risk reduction. Interface Focus. 2022;12(1):20210042. doi: 10.1098/rsfs.2021.0042.
37. Biryukov J, Boydston JA, Dunning RA, Yeager JJ, Wood S, Reese AL, et al. Increasing temperature and relative humidity accelerates inactivation of SARS-CoV-2 on surfaces. mSphere. 2020;5(4):e00441-20. doi: 10.1128/mSphere.00441-20.
38. Roy A, Parida SP, Bhatia V. Role of disinfection and hand hygiene: a COVID-19 perspective. Int J Community Med Public Health. 2020;7(7):2845-9. doi: 10.18203/2394-6040.ijcmph20203025.
39. Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The effects of temperature and relative humidity on the viability of the SARS coronavirus. Adv Virol. 2011;2011:734690. doi: 10.1155/2011/734690.
40. Yang W, Marr LC. Mechanisms by which ambient humidity may affect viruses in aerosols. Appl Environ Microbiol. 2012;78(19):6781-8. doi: 10.1128/aem.01658-12.
41. Schulz C, Conrad A, Becker K, Kolossa-Gehring M, Seiwert M, Seifert B. Twenty years of the German Environmental Survey (GerES): human biomonitoring--temporal and spatial (West Germany/East Germany) differences in population exposure. Int J Hyg Environ Health. 2007;210(3-4):271-97. doi: 10.1016/j.ijheh.2007.01.034.
42. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med. 2020;382(16):1564-7. doi: 10.1056/NEJMc2004973.
43. Gavaldà-Mestre L, Ramírez-Tarruella D, Gutiérrez-Milla C, Guillamet-Roig F, Orriols-Ramos R, Tisner SR, et al. Nondetection of SARS-CoV-2 on high-touch surfaces of public areas next to COVID-19 hospitalization units. Am J Infect Control. 2021;49(6):840-2. doi: 10.1016/j.ajic.2021.01.007.
44. Harvey AP, Fuhrmeister ER, Cantrell ME, Pitol AK, Swarthout JM, Powers JE, et al. Longitudinal monitoring of SARS-CoV-2 RNA on high-touch surfaces in a community setting. Environ Sci Technol Lett. 2021;8(2):168-75. doi: 10.1021/acs.estlett.0c00875.
45. Hennessy NT, Toomey S, Gautier V, O'Reilly S, de Barra E, Hanrahan EO, et al. COVID-19 contamination of high-touch surfaces in the public domain. Ir J Med Sci. 2022;191(6):2839-40. doi: 10.1007/s11845-021-02881-z.
46. Montagna MT, De Giglio O, Calia C, Pousis C, Apollonio F, Campanale C, et al. First detection of severe acute respiratory syndrome coronavirus 2 on the surfaces of tourist-recreational facilities in Italy. Int J Environ Res Public Health. 2021;18(6):3252. doi: 10.3390/ijerph18063252.
47. da Silva SJ, do Nascimento JC, Dos Santos Reis WP, da Silva CT, da Silva PG, Mendes RP, et al. Widespread contamination of SARS-CoV-2 on highly touched surfaces in Brazil during the second wave of the COVID-19 pandemic. Environ Microbiol. 2021;23(12):7382-95. doi: 10.1111/1462-2920.15855.
48. Di Carlo P, Chiacchiaretta P, Sinjari B, Aruffo E, Stuppia L, De Laurenzi V, et al. Air and surface measurements of SARS-CoV-2 inside a bus during normal operation. PLoS One. 2020;15(11):e0235943. doi: 10.1371/journal.pone.0235943.
49. Noorimotlagh Z, Mirzaee SA, Seif F, Kalantar M, Roghani T, Mousavi SA, et al. Detection of different variants of SARS-CoV-2 RNA (genome) on inanimate surfaces in high-touch public environmental surfaces. Sci Rep. 2023;13(1):13058. doi: 10.1038/s41598-023-40342-y.
50. Viana Martins CP, Xavier CSF, Cobrado L. Disinfection methods against SARS-CoV-2: a systematic review. J Hosp Infect. 2022;119:84-117. doi: 10.1016/j.jhin.2021.07.014.