Detection of Severe Acute Respiratory Syndrome Coronavirus 2 from the Surface of Hospitals and Public Facilities during the COVID-19 Pandemic in Eastern Ethiopia: Evidence for Surface Transmission

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Abstract

Background: Humans acquired Severe Acute Respiratory Syndrome Coronavirus 2 through respiratory droplets expelled by infected individuals during coughing, sneezing, and touching contaminated surfaces. However, there is no available data regarding environmental surface contamination in hospitals and public facilities in Ethiopia. Therefore, this study aimed to detect Severe Acute Respiratory Syndrome Coronavirus 2 on the surfaces of hospitals and public facilities in eastern Ethiopia during the Coronavirus-19 pandemic, from April 15 to May 15, 2021.

Methods: A cross-sectional study was undertaken, involving the collection of 384 swab samples from commonly touched surfaces in selected areas such as hospitals, automated teller machines, public transport, and game zones. The presence of viral nucleic acid was identified using a Reverse transcription-polymerase chain reaction. Subsequently, descriptive statistics were employed to summarize the findings

Results: The overall contamination of the swab environmental surfaces in hospital and community facilities with Severe Acute Respiratory Syndrome Coronavirus 2 was 12% (95% CI: 8.7, 15.2%). The virus was detected in 29.1% (32/110), of hospitals (3.6%, 1/28), automated teller machines (1.8%, 4/219), public transport, and 33.3% (9/27) of game zones. Surfaces in the surgical ward (5/6) from the hospital and gaming zone (33.3%) from the community facility were more commonly contaminated by Severe Acute Respiratory Syndrome Coronavirus 2.

Conclusions: In this study, more than one in ten of the screened environmental surfaces were contaminated with SARS-CoV-2. Surfaces in hospitals and gaming areas have significant Severe Acute Respiratory Syndrome Coronavirus 2 levels. There are strong preventive and control measures focusing on the cleaning of hand contact surfaces using appropriate chemicals to avoid viral spread across the population.

***Keywords*:** COVID-19, SARS-CoV-2, environmental contamination, hospital, public facilities, Harar

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Introduction

In December 2019, a new strain of coronavirus called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) caused the Coronavirus Disease 2019 (COVID-19) and an outbreak was reported from Wuhan city, in the Hubei province of China (Xie *et al*., 2020). The pandemic has spread worldwide, posing worldwide health threats (Lai *et al*., 2020; Iwasaki *et al*., 2020).

The worldwide pandemic COVID-19 is quickly becoming a key public health problem for many countries. Over 4.51 million deaths have been documented as of September 2, 2021(WHO, 2020c), with one-third of the world's population under lockdown (Rizou *et al.*, 2020). As of September 2, 2021, the overall number of cases in Africa is over 5.6 million, with over 308,000 cases and 4,675 deaths in Ethiopia (EPHI, 2021).

The virus has several hosts, such as birds, rodents, reptiles, and humans (Yesilbag *et al*., 2020). The modes of transmission of SARS-CoV-2 among humans are mainly through respiratory droplets produced by infected individuals with sneezes or coughs (Guo *et al*., 2020) and through hand contact of objects surface of contaminated with virus and touching the mouth, nose, or eyes (Tanne, 2020). Infected humans may experience symptoms after an incubation period, which could vary from 2 to 14 days and, in rare cases, exceed 29 days (Fiorillo *et al.,* 2020). The most common clinical manifestations of patients with COVID-19 are fever, cough, shortness of breath, fatigue, and eventually death from acute respiratory distress syndrome and organ failure (Wan *et al*., 2020). Different prevention

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measures, such as wearing masks, social distancing, and frequent hand washing, were implemented (Fiorillo *et al.,* 2020). Furthermore, minimizing contact with potentially contaminated surfaces, hand hygiene after surface contact, and environmental cleaning and disinfection are recommended to reduce the transmission of SARS-CoV-2 (CDC, 2020a).

Hospitalized patients with COVID-19 may contaminate the environment and materials and pose a risk to hospital communities (Wei *et al*., 2020). The virus had been detected on the surfaces of objects in asymptomatic patients' rooms and toilet areas (Guo *et al*., 2020). Hospital floors, and high-touch surfaces material (Redmond *et al.,* 2020). The level of contamination of the hospital setup and community environment by the SARS-CoV-2 virus is not well explored (Wei *et al.,* 2020). Similarly, to our knowledge, there is no data on the level of contamination of the hospital and community surfaces in Ethiopia. Therefore, this study was conducted to detect SARS-CoV-2 on the surfaces of hospitals and public facilities in Harar City, eastern Ethiopia during the COVID-19 pandemic.

Materials and Methods

Study Setting, Design, and Period

A cross-sectional study was conducted on selected frequently touched environmental surfaces from Hiwot Fana Comprehensive and Specialized University Hospital and community facilities in Harar City, eastern Ethiopia, from April 15 to May 15, 2021. Harari Regional State is located 526 kilometers from Addis Ababa. According to demographic projections, the total population of the Harari region in 2022 is expected to be 276,000 (UNICEF, 2019).

Population, Sample Size, and Sampling Technique

The study population was randomly selected environmental surfaces that can touched by people, in a hospital and community. The sample size was calculated using a single population proportion formula with the assumptions of a 95% confidence level, a 5% margin of error, and since no study has been conducted, a 50% prevalence was taken. Therefore, the final sample size of 384 environmental surfaces was included in this study. A stratified sampling technique was used to collect swab samples from the hospital setting and community facilities. Then the sample was proportionally allocated between those four strata, namely, hospitals (110), automated teller machines (ATMs) (28), public transport (219), and game zones (27). Based on the inclusion criteria, environmental surface samples were collected (Figure 1).

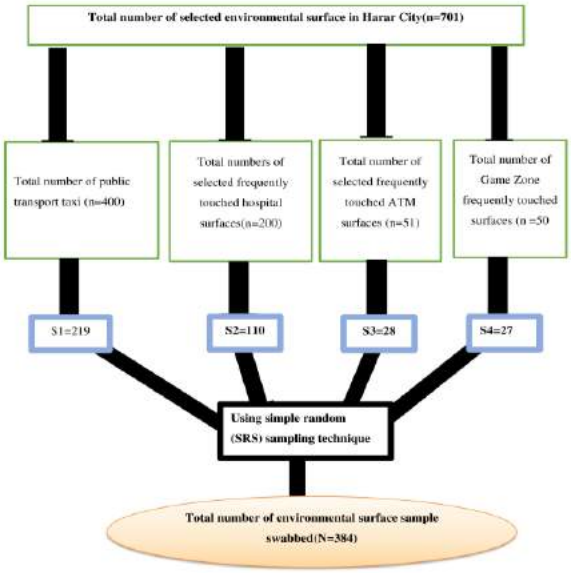


Figure 1: Schematic representation of sampling procedure.

Data Collection Techniques

Data were collected by the following method;

Sample collection, handling, and transportation: Environmental surface samples were collected by four Bachelor of Sciences. medical laboratory professionals follow all biosafety instructions, by using personal protective equipment, like a protective gown, a respirator mask, and gloves and hand hygiene (WHO/PAHO, 2020).

Swab samples were collected from selected hand touched surfaces from the hospital and community. From the hospital, the swab sample was collected from inanimate objects such as door surfaces, handles, window handles, and chairs that are found in different hospital surfaces locations such as the COVID-19 isolation room, radiology department, internal medicine ward, pediatric ward, surgical ward, intensive care unit, neonatal ward, obstetrics ward, COVID-19 treatment center, endoscopy room, dermatology unit, emergency department, Antiretroviral Therapy and gynecology ward. In the community, swab samples were collected from handles and surfaces of public transport, screens and touchpads of ATMs, chess, and

pool table balls. Swab samples were placed in a viral transport medium (VTM) and transported in a cold box to the Hararghe Health Research molecular laboratory within 2 hours. In the laboratory, samples were processed upon arrival or stored at -70 °C until processed (WHO/PAHO, 2020).

Laboratory Analysis

Nucleic acid extraction: Nucleic acid extraction was conducted by the DaAn extraction kit (DaAn Gene Co., Ltd., China, catalog number ETP202001) following the manufacturer's instructions. In summary, lysis solution contains a strong protein denaturant, which can quickly dissolve protein and make nucleic acid dissociated. Under the existence of lysis solution and ethyl alcohol, the dissociated nucleic acid compositions can be combined on the silicon membrane, and then, by the actions of the inhibitor remover and deionized solution, the protein, inorganic salt ions, and many organic impurities can be removed. The final elution was made with 50 µl of elution buffer (DaAnGene, March, 2020).

Master-Mix: A master mix containing PCR mix and enzyme mix Beijing Genomics Institute (BGI), China) was used as an ingredient in Reverse transcription-polymerase chain reaction (RT-PCR) according to the manufacturer's instructions. Primers and sequence-specific fluorescence probes were designed to target the N-gene, a region that is highly conserved among different strains of SARS-CoV-2. Accordingly, 18.5 µl PCR mix and 1.5 µl enzyme mix were mixed to prepare a master mix, and 10 µl template was added. Both negative and positive controls were added following the manufacturer's instructions. The final reaction volume was 30 µl.

Amplification, and result interpretation: The Quant Studio 7 Flex System (Thermo Fisher, India), a fluorescent-based polymerase chain reaction (PCR), was used to detect the target N-gene of SARS-CoV-2 (Life Technologies, 2013). The result was interpreted negative when the test sample did not have an amplification curve or a cycle threshold (Ct) value > 38 in the two fluorescent dye namely fluorescein amidite (FAM) and Victoria (VIC) channels and as positive for 2019 Novel Coronavirus (2019-nCoV) RNA when there was a test sample with an evident amplification curve FAM and VIC channels and a Ct value ≤ 38 according to the manufacturer's instructions. Each experiment was carried out in combination with a negative or positive control (LifeTechnologies, 2013).

Data Quality Control

Training was provided to all sample collectors and supervisors by the principal investigator and senior medical laboratory technologist for two days on the sample collection tools and procedure before the actual data collection. Standard Operating procedures were followed strictly during the extraction and detection process. Blank control Ct values at FAM and VIC channels were used. Positive control standard curves at FAM and VIC channels are in S-shape with a Ct value not higher than 32. Testing specimen (internal control reference) standard curve at VIC channel in S shapes with Ct not higher than 32. The above requirements were checked and met in a single sample; otherwise, the test was invalid.

Data Processing and Analysis

The data were entered into EpiData version 4.6, cleaned, and exported to SPSS version 25 for analysis. Descriptive statistics, such as frequency and percentage, were calculated for various environmental locations and presented in tables and graphs for categorical variables. For continuous variables, the mean ± standard deviation or median (interquartile range) was determined. Consequently, the magnitude of SARS-CoV-2 was determined as the proportion of those environmental surface samples reported to have SARS-CoV-2.

Ethical Consideration

Ethical clearance was obtained from the Institutional Health Research Ethical Review Committee of Colleges of Health and Medical Sciences, Haramaya University (IHRERC/) with Ref. No. IHRERC/204/2022. Hospital and community facility were fully informed about the purpose of the study and signed their consent.

Results

Magnitude of SARS-COV-2 from Swabbed Surfaces

A total of 384 swab samples were collected from selected possibly hand touched surfaces of hospital environmental and community facilities. The majority of the surface swab samples were collected from public transport (57%), and hospital environments (28.5%). The overall magnitude of SARS-CoV-2 from all

swabbed surfaces was 12% (95% CI: 8.7%, 15.2%). The highest magnitude of SARS-CoV-2 was detected from the game zone surface (33.3%). However, 1.8% of SARS-CoV-2 was detected on public transport surfaces (Table 1).

Table 1: SARS-CoV-2 RNA detection from selected hand touched swabbed surfaces in the community facilities and hospital, eastern Ethiopia, 2021 (n= 384)

Surface location name	**RT-PCR test result**	
	Negative N (%)	Positive N (%)
Hospital environment surfaces	78(70.9%)	32(29.1%)
Automated Teller Machine surfaces	27(96.4%)	1(3.6%)
Public transport surfaces	215(98.2)	4(1.8%)
Game zone surfaces	18(66.7%)	9(33.3%)

Detection of SARS-COV-2 from sampled surface in Hospital environmental

Swab samples collected from 110 frequently touched surfaces in the hospital, including door handles, chairs, beds, windows, toilet seats, and water taps, revealed a notable detection of SARS-CoV-2.The virus found on 3 out of 8 COVID-19 isolation rooms, 2 out of 4 radiology department rooms, 1 out of 6 internal medicine ward rooms, 5 out of 6 surgical ward rooms, 1 out of 4 intensive care unit rooms, 5 out of 8 neonatal ward rooms, 3 out of 6 obstetrics ward rooms, 5 out of 14 COVID-19 treatment center rooms, 1 out of 3 endoscopy rooms, 1 out of 2 dermatology unit rooms, 1 out of 14 emergency department rooms, 1 out of 8 ART Pharmacy rooms, 1 out of 5 orthopedics rooms, and 1 out of 2 Card Room. Door handles 12(29.2%), chairs 9(30%), and beds 9(32.1%) exhibiting the high viral detection (Table 2). However, the virus was not detected on surfaces in the pediatric ward, orthopedics, laboratory, and gynecology Ward.

Table 2: Table 2: SARS-CoV-2 RNA detection from selected surfaces swabbed at Hospital, eastern Ethiopia, 2021, (N=110)

Characteristics	**Surface swabbed**	**RT-PCR Result**	
		Negative N(%)	**Positive N(%)**
Frequently touched hospital environmental	Door Handles	29(70.7)	12(29.2)
	Chair	21(70)	9(30)
	Bed	19(67.9)	9(32.1)
	Window	8	-
	Toilet seat	1	1
	water tap	-	1
	Total	**78(70.9)**	**32(29.1)**

Detection of SARS-COV-2 from the surface sampled at Community

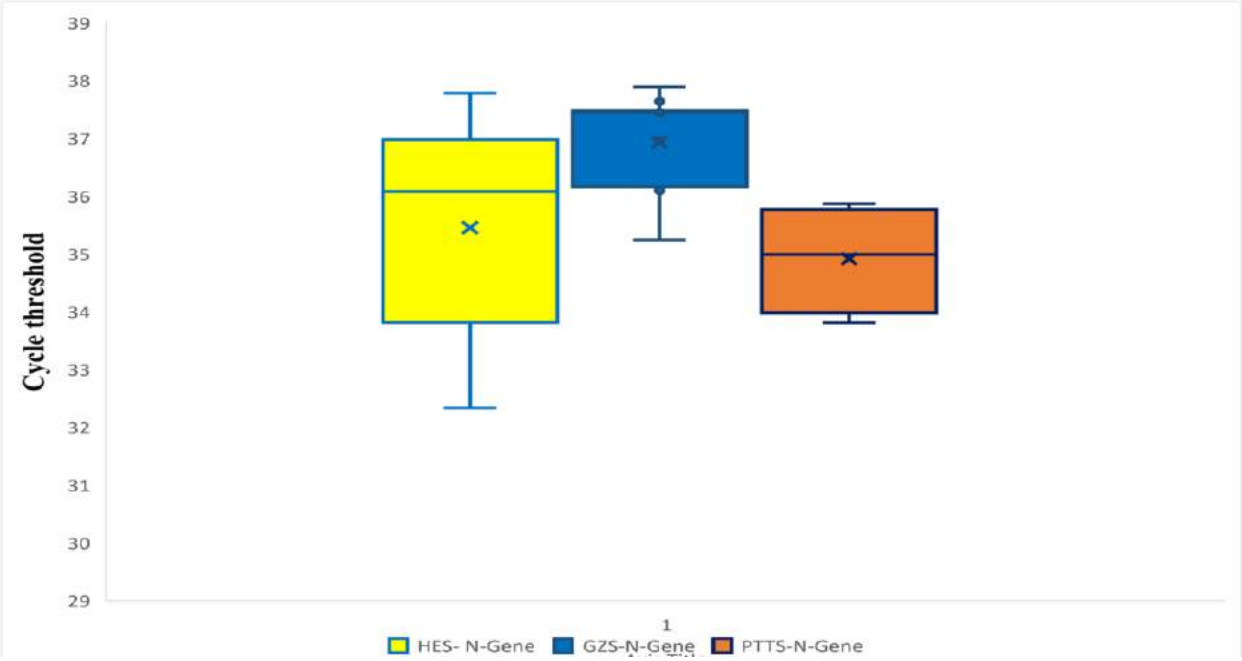
The most SARS-CoV-2 RNA was detected from the swabbed surfaces of pool sticks and white balls in the community public pool house. In contrast, the handles public transportation had the lowest levels of SARS-CoV-2 contamination (Table 3).

Cycle threshold of samples Positive for SARS-CoV-2

A total of 46 positive swab samples were subsequently examined for cycle threshold (Ct) values. The mean Ct values of N-gene identified from the hospital surfaces, game zone, and public transport were 35.1, 36.9, and 34.9, respectively (Figure 2).

Table 3: SARS-CoV-2 RNA detection from the selected swabbed surface in the community facilities, Eastern Ethiopia, 2021 (n= 384).

Swabbed Surface location	Surface swabbed	PCR Result	
		Negative N (%)	Positive N (%)
Game Zone Surfaces	Pool stick	15 (68.2)	7(31.8)
	White ball	-	2
	Chess	3	-
Public transport Taxis	Handles	215 (98.2)	4 (1.8)
Automated Teller Machine	Keypad & screen	27 (96.4)	1 (3.6)



HES N-gene: Hospital Environmental surfaces- N-Gene, GZS: Gaming zones surfaces-N-Gene, PTTS-N-gene: Public transportation taxis surfaces-N-Gene

Figure 2. Cycle threshold values of hospital environmental surfaces, gaming zones surfaces, and public transportation taxi surface samples for SARS-CoV-2 RNA detection using RT-PCR, Eastern Ethiopia, 2021

Discussion

The overall SARS-CoV-2 detection on the swabbed surface was 12% (95% CI: 8.7, 15.2). The detection of SARS-CoV-2 on hospital surfaces, public transport surfaces, game zone surfaces, and ATM surfaces was 29.1%, 1.8%, 33.3%, and 3.6%, respectively. There were notable variations in the cycle threshold across the several swabbed surfaces. Specifically, the hospital surface sample exhibited a higher viral load which was indicated with lower cycle threshold compared to the non-hospital samples. This observation imply a greater level of viral contamination of the hospital environment. This can be explained by the fact that COVID-19-hospitalized patients can potentially contaminate the hospital environment when they cough, sneeze, talk, or breathe. These droplets can land on surfaces and objects, leading to potential contamination (WHO, 2020b).

In the present study, SARS-CoV-2 was detected on 29.1% of hospital surfaces. This finding is consistent

with the study done in Italy (24.3%) (Razzini *et al*., 2020). However, It is higher than two separate studies conducted in China 13.6 % (Ye et al., 2020), 3.1% (Luo *et al*., 2020), and Singapore (14%) (Ong *et al*., 2020). Furthermore, this study's findings are lower than those reported from China (38%) (Wu *et al*., 2020). This disparity might be due to differences in COVID-19 prevention and strength of implementation control (Chowdhury and Jomo, 2020), economic status knowledge, and practice about SARS-CoV-2 (Mena *et al.,* 2021).

According to the present data, the surgical ward had the greatest level of contamination 5/6, followed by the neonatal ward 5/8 use percentage for comparison These findings are different from the findings reported from China which found greater SARS-COV-2 levels in the intensive care unit (ICU) and obstetrics ward(Ye *et al.,* 2020). The variation in findings could be attributed to differences in the strength of infection prevention measures applied in health facilities set up (WHO, updated on 13 August 2021).

The detection rate of SARS-CoV-2 from a swabbed door handle was 10.9% in the current study. This was lower than reported from Italy (25.0%) (Razzini *et al*., 2020). The disparities might be attributed to a greater number of COVID-19 cases in Italy, the most affected European country (Chu, 2021). SARS-CoV-2 was found to be more prevalent on hospital surfaces than on community facilities in this study. Similar finding was reported from China (Zou *et al*., 2020). This could be due to visitors and attendants may get an infection from the hospital environment by contacting inanimate surfaces other than the communal facilities (WHO, 2020a). Furthermore, the hospital surface may have a role in the nosocomial transmission of SARS-COV-2 among patients, attendants, and the hospital population (Chia *et al*., 2020). SARS-CoV-2 virus load was also greater in hospital surfaces than in the community. As a result, the risk of contracting the virus from the hospital surface may be greater than in community settings (Zou *et al*., 2020).

In the present study, the detection of SARS-CoV-2 from ATMs was 3.6% among surfaces in facilities. Swabbed. This was lower than a report from 10% report from Saudi Arabia (Elbadawy *et al*., 2021). Furthermore, the pool house had a higher SARS-COV-2 infection rate (33.3%). Pool houses are in the game zone where adolescents and young people go to play. Even if these people are not afflicted by SARS-CoV-2 or show fewer symptoms, they can spread the virus to family members, particularly elderly people, and other groups (Viner et al., 2020). The greater contamination might be due to less follow-up of SARS-Cov-2 infection prevention (CDC, 2020b, WHO, 2020). A study conducted in China found that hand-washing with soap can remove 98.4% of the virus from the hand (Ma *et al*., 2020).

In general, community and institutional negligence and lack of engagement in the effective implementation of COVID-19 prevention and control contribute to the transmission of the virus within the community (Sidamo *et al*., 2021).

Strengths and Limitations of the Study

This study is the first to address SARS-CoV-2 surface-level contamination detection in both hospital and community settings in Ethiopia. The study uses RT-PCR techniques, which are sensitive and specific to detecting SARS-CoV-2 on environmental surfaces. However, the RT-PCR, could not confirm the viability of the virus on the studied surfaces. This needs viral culture.

Conclusion

In this study more than one in ten of the swabbed environmental surfaces contaminated with SARS-CoV-2. Hospitals and gaming swabbed surfaces have significant levels of SARS-CoV-2. Surfaces in the hospital's surgical ward and surface of the hospital door handle had a higher level of contamination. Hospital surfaces had a higher viral load of the SARS-CoV-2 virus than swabbed surface from community surfaces. Therefore it is crucial to implement strong prevention and control measures l including surface hygiene practices with appropriate chemical and other preventive measures, such as mask-wearing, physical distancing, and vaccination, to effectively reduce the risk of virus transmission at community and health facility set up.

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Competing Interests

The authors declare that they have no competing interests.

Funding Statement

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Authors' Contributions

F.A. conceived the study, designed the study, and performed data collection, and analysis. D.A.A and Z.T. drafted the manuscript and critically revised the design of the study. M.B. and M.D. supported the analyses, and interpretation of the findings revised the manuscript. All authors contributed.

List of Abbreviations

ATM: Automated Teller Machine, COVID-19: Coronavirus Disease 2019 ICU: Intensive Care Unit, RT–PCR: Reverse Transcription-Polymerase Chain Reaction, SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus, WHO: World Health Organization.

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