

Original Research Article

COVID-19 outbreak investigation in a quarantine facility: is SARS-CoV-2 exhibiting lesser known routes of spread?

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ABSTRACT

Background: An institutional quarantine facility in India reported 5 cases in 9 days. The latter 2 cases incited a suspicion of internal outbreak as they were residing in a different room than the index cases and onset of symptoms was after the expiry of quarantine period. Subsequently, 75 more cases tested positive from this facility.

Methods: A retrospective-prospective study was conducted. Data regarding the travel history, health-events thereafter, daily activities, layout of the facility and standard procedures followed in the facility was collected. The epidemiological pattern of presentation and evolution of cases was studied.

Results: The outbreak pattern and investigation revealed a common bathroom as the cause of intra-floor spread. Inter-floor spread was also observed and 93.75% cases were detected from rooms using their floor bathrooms located vertically below one another and interconnected by plumbing systems. SAR for room contacts of index cases was 90% and SAR was 82.14% for bathroom contacts of index cases. The positivity rate amongst individuals assigned bathroom number 1 on the floors vertically located below the top floor was 64.10%.

Conclusions: The investigation and results show local spread of SARS-CoV-2 through usage of common bathroom facility. An interesting trend of inter-floor spread with concentration of cases only in the rooms dedicated to vertically located bathrooms was found which indicates spread through waste-water plumbing system, a phenomenon previously observed in SARS-CoV in 2003. Single floor quarantine facilities are recommended with lesser dependency on common bathrooms.

Keywords: COVID-19, SARS-CoV-2, Outbreak, Quarantine facility, Waste-water plumbing system

INTRODUCTION

COVID-19 is an illness which is known to spread through the respiratory route via droplet infection or fomites. Recent studies have supported possibility of aerosol transmission of the virus as well.¹⁻³ Routes of transmission other than these have also been suspected due to detection of SARS-CoV-2 in waste-water, sewage samples and rectal swabs.⁴⁻⁸ Less commonly known

modalities of spread like water-borne and aerosolisation in plumbing systems have been contemplated. The SARS virus from 2003 is known to have a considerable similarity in genetic makeup to SARS-CoV-2 and considered to spread through plumbing systems.⁹ A study in June 2020 showed significant observed mutations per sample in India as compared to the world average. It is not known if these mutations can significantly affect the property of the virus in terms of route of transmission.

In case of SARS-CoV-2, a maximum consensus has been established for a mean incubation period of 5.1 days.¹⁰ A maximum incubation period of 14 days has been considered for purposes of quarantine to identify 99% of cases developing COVID-19.¹¹ The maximum incubation period exhibited by the pathogen corresponds to the period until which a person with suspected or confirmed exposure is quarantined. Quarantine is defined as segregation of asymptomatic suspects for the maximum period in a disease during which they are likely to develop symptoms. Quarantine facilitates the control of spread from infected persons. The person is watched for development of symptoms and is released if asymptomatic at the end of quarantine period. Quarantine can be home or institution based. Institutional quarantine consists of a number of suspects being quarantined in a common facility under observation. Depending on the standard procedures, lay out, personal protective and preventive measures the chances of in-house spread in the quarantine can be high or low. The extent of transmission may also depend on the strain or sub-strain of the pathogen.

In the case of SARS-CoV-2, social distancing, wearing of masks, personal protective equipment in staff, hand sanitization and early detection/reporting of symptoms are some of the basic requirements in standard procedures inside a quarantine facility. Procedures for delivery of food, usage of bathroom facilities and collection of waste are extremely important and should be planned and executed with extreme caution. Awareness in individuals, motivation to declare symptoms and maintenance of good morale and mental health are a challenge in such facilities. Lack of proper infrastructure for quarantine in such situations and ad hoc conversions of buildings which were not meant for quarantine may result in further challenges.

This epidemiological investigation was conducted in Dehradun, India from June 2020 to August 2020, in view of an outbreak in an institutional quarantine facility which was a converted school building, spread over three floors. The quarantine facility initially reported 5 cases within the first 9 days, 2 of which were termed index cases for the purpose of the study since they reported simultaneously on 18 June with symptoms. This was followed by 78 more positive cases who reported/tested from 25 June onwards. The aim of the investigation was to determine the presence and pattern of local spread, control the outbreak, detect the cause and suggest measures for improvement in standard procedures.

METHODS

The outbreak investigation and subsequent retrospective-prospective study was carried out during the period June 2020 to August 2020 at an institutional quarantine facility in Dehradun city, India. This quarantine facility was converted from a school building with ground, middle and top floors having 20, 21 and 20 rooms respectively.

Each room measured 27 feet (length) × 20 feet (breadth) × 12 feet (height) in its dimensions and was allotted to 5-6 persons of similar arrival date. The arrival dates of all persons were on either of the dates of 8, 9 or 10 June and the expiry of the quarantine period of all individuals was determined as 24 June for uniformity. This quarantine facility was an appropriate centre for the study because it accommodated 358 individuals from all over India since these individuals worked in a multi-state organization in the city. The protocol being followed was that all individuals, if asymptomatic after completion of an uneventful 14-day quarantine period, would be dispatched out of the quarantine together to their respective workplace/homes. They were not exposed to any fresh arrivals during this period.

A case of COVID-19 was defined as a person with laboratory confirmation of COVID-19 infection, irrespective of clinical signs and symptoms.^{12,13} The confirmatory test for COVID-19 was done by subjecting nasopharyngeal/oropharyngeal samples to real-time Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR).¹⁴ Contacts for the purpose of contact tracing were defined as per WHO Interim Guidance on contact tracing and guidelines issued by National Centre for Disease Control, Ministry of Health and Family Welfare, Government of India on their official website.^{15,16} Secondary attack rate (SAR) was calculated as the number of cases divided by the number of exposed contacts. This was calculated with respect to the index cases wherein they transmitted infection to room-contacts and bathroom contacts.

Symptoms specific to COVID-19 for investigation and application of containment strategy were defined as presence of fever, cough and breathlessness either singly or in combination.¹⁷⁻¹⁹ The day of onset of symptoms was defined as the first day of realization of any of the above symptoms by the individual. The potential infectious period was defined to begin from 48 hours prior to onset of symptoms till 14 days later.¹⁵ Contact tracing was carried out from the beginning of the potential infectious period until isolation of the individual. Secondary attack rates were calculated for the following groups: (a) a room cluster wherein room contacts of the index cases subsequently reported positive, and (b) a bathroom cluster wherein bathroom contacts of the index cases reported positive. All such contacts should have developed symptoms or tested positive after the expiry of their quarantine period with respect to their arrival date and within the incubation period after contact with the index case.

Positive cases were shifted from the quarantine facility to the hospital immediately after detection. All contacts were tested between days 5 to 14 of the last day of contact with the confirmed case. Containment measures and active surveillance was initiated after outbreak of unknown extent was established. This included testing

everyone in the facility to prevent all chances of any infected case getting released undetected.

Case interviews were carried out for cases and contacts for epidemiological history. Environmental survey was carried out to study the layout of the quarantine facility, floor design, layout of room, layout of bathroom and standard procedures for essential services. All data was recorded in an epidemiological case sheet, analysed and interpreted. Statistical analysis was performed using Epi Info 7.0. Informed consent was taken from all participants and ethical clearance was obtained from the concerned hospital ethical committee.

RESULTS

The age of the 358 occupants ranged from 21 to 46 with a mean and standard deviation of 29.79 ± 7.07 . All 358 individuals of the quarantine eventually had undergone testing by RT-PCR. 80 individuals (22.35%) tested positive out of which 22 individuals (27.5%) had developed symptoms at some point and 58 individuals (72.5%) never developed symptoms. All symptomatic cases had reported within 12 hours of the onset of their symptoms. The age of the positive cases ranged from 21 to 46 with a mean and standard deviation of 31.69 ± 6.81 . The pattern of reporting of cases with symptoms was plotted as an epidemic curve (Figure 1).

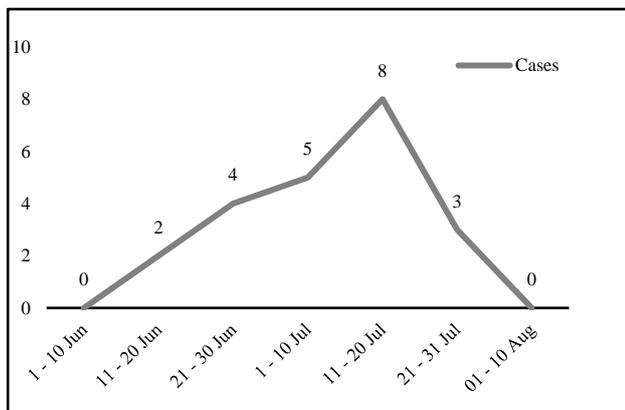


Figure 1: Pattern of reporting of cases with symptoms (22 cases).

Each floor in the facility had four bathrooms (bathroom number 1, 2, 3 and 4), each nominated for 5-6 rooms. The bathrooms had 6-8 compartments (with toilet seats) and all seats nominated to around 5-6 individuals. Different time slots were allotted to different rooms for usage of the common facility. Bathing was being done in the bathroom as per time slots in the foyer of the bathroom by using a bucket and mug. The distance between two adjacent beds in the rooms was 2.5 meters. Individuals were instructed to have only essential interaction between themselves from a distance and wear triple layer cloth masks at all times possible. Delivery of food was ensured in full PPE by an attender, nominated for each portion of the floors. There was no direct interaction between the attender and

the room occupants. The tiffin boxes were used, washed and kept back at the doorstep for the attender in full PPE to collect it for direct disposal to the disinfection area outside the quarantine facility. The tiffin was disinfected adequately and re-used. Daily disinfection was also carried out by housekeepers in full PPE for the floor and the bathrooms. All disinfection was carried out by 1% sodium hypochlorite solution.

The two index cases reported with symptoms of fever with cough and fever on 18 June from room numbers 1 and 3 respectively and were the only ones to develop symptoms during the quarantine period from the date of arrival. They were hospitalized on 19 June. One primary room contact of the index case from room number 3 reported with symptoms on 25 June. Subsequently on 27 June, 2 individuals from room number 2 (top floor) developed symptoms and were found to be positive. This event confirmed a spread through the common bathroom since on intensive interviewing of the individuals it was ascertained that the common bathroom was the only point of contact with the index cases. Also, since these two individuals developed symptoms beyond the expiry of the quarantine period with respect to their arrival dates, there were high chances it was a locally contracted infection. The event was termed as outbreak and containment measures were implemented. During this period, supervision and monitoring of preventive measures was enhanced. The facility was barred from entry and exit. The implicated bathroom on top floor was sealed. Affected rooms on the top floor (room number 1 to 5) were sealed and all primary contacts awaiting testing from these rooms were shifted to a different adjacent building. The building was facilitated with CCTV monitoring, floor sentries to monitor the already sealed inter-floor thorough fare and a central public address system to impart daily awareness.

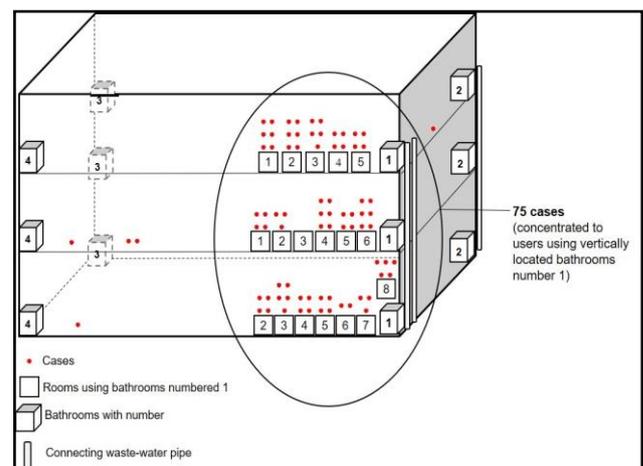


Figure 2: Mapping of cases in a figurative representation of the quarantine facility (not to scale).

By the first week of July, a total of 25 out of 30 individuals from room numbers 1 to 5 on the top floor, using the common bathroom facility (bathroom number

1) tested positive. Out of these, 2 were index cases who developed symptoms during their quarantine period (with respect to arrival date), 9 persons were room contacts and 14 persons were bathroom contacts. This phenomenon established spread between persons using the same bathroom facility in addition to intra-room spread. Subsequently, 55 more quarantined persons from all floors tested positive. This included both symptomatic and asymptomatic cases. The total positive count in the facility was now 80 with 26, 26 and 28 cases on the top, middle and ground floors respectively and the cases were mapped (Figure 2).

The striking observation noticed in the distribution of cases was that a total of 75 out of 80 cases (93.75%) were concentrated to rooms which used bathrooms numbered 1 located vertically below each other. These rooms were room numbers 1-5 on top floor, room numbers 1-6 on middle floor and room numbers 2-8 on ground floor. There was no unaffected room which used bathroom numbered 1 on any floor. The positivity rate among individuals assigned bathroom number 1 on the floors vertically located below the top floor i.e. ground and middle floors, was 64.10%. The SAR with respect to room contacts contracting the infection from index cases was 90% and the SAR with respect to bathroom contacts (on the top floor) was 82.14%. The administrative staff, tiffin distributors and attenders for all floors tested negative for antigen and antibody. There was no breach on PPE by the administrative staff at any level.

There were 5 cases which did not follow this pattern and were found sporadically in other parts of the facility in rooms which were using other bathrooms. The congregation of cases in the set of rooms using bathroom number 1 on all floors located vertically below each other due to possible common exposure was strongly significant statistically at $p < 0.05$ and not merely by chance (Chi square value=194.04, odds ratio=111.36, RR=34.72, $p < 0.00001$ at 95% CI and 5% alpha error).

DISCUSSION

The outbreak affected a total of 80 persons in the quarantine out of which two index cases reported first with symptoms simultaneously from room numbers 1 and 3 from top floor on 18 June. The investigation revealed intra-room, intra-floor and inter-floor spreads starting from the top floor. The investigation also revealed that persons contracted the virus from cases within the rooms and common bathrooms with a significant concentration of cases using bathrooms connected by a common defective pipeline. The healthcare workers, administrative staff, tiffin distributors and attenders for that floor also tested negative for both antigen and antibody ruling out the staff being a source for spread to various rooms. The only common link for intra-floor spread after intensive case interviews and investigation between the occupants of these rooms was the use of common bathroom (bathroom number 1 on top floor). Ear-marking and time-

slotting in bathrooms did not have any affect to prevent the spread. Activities in the bathroom involved spitting, rinsing, clearing of mucus from nose and throat, defecation and bathing. Transmission by droplet infection and fomites is one of the well documented modes of transmission of SARS-CoV-2 and seemed to play the role in the horizontal spread on the top floor as well as spread within the rooms.

The investigation also revealed that 75 out of these 80 cases (93.75%) were concentrated to specific flanks located vertically below each other belonging to rooms using bathrooms numbered 1 on each floor which were interconnected to each other along with the bathroom number 1 of the top floor by inter-connected waste-water plumbing systems (one for water drainage and one for sewage). In absence of any common person frequenting between these flanks, and mixing of individuals from different floors with one another (evidence being floor attendants/sentries and CCTV cameras), any role of droplet infection or fomites was ruled out. Airborne spread for SARS-CoV-2, which is still not officially globally confirmed, can explain distant spread to some extent but it cannot explain concentration of cases to only one side of the building vertically below one another.³ Since all staff had tested negative, their role in the spread was also ruled out.

The absence of evidence for the above modes of transmission led to the epidemiological conclusion of a lesser known mechanism (earlier observed in SARS-CoV from 2003) i.e. spread of SARS-CoV-2 from one bathroom to the other located vertically below each other and interconnected by common waste-water pipes which carried drainage including spitted, mucus laden, rinsed, defecated drainage/sewage water.²⁰⁻²³ This led to the consideration of possible property of the virus to be present and travel through drainage/sewage pipes and even enter into other compartments (vertically located bathrooms) which are interconnected through plumbing systems. Continuous use of exhausts can increase the phenomenon by providing mild air-pressure gradient. This gives rise to a possible mode of waste-water aerosol inhalation route. The drainage and sewage pipes were inspected for all bathrooms in the facility. The U-bends and seal traps were also inspected. It was revealed that the affected flanks had drainage/sewage being transmitted through rusted old iron pipes whereas other flanks had new PVC pipes. There was lack of proper U-bends in the bathroom appliances and leakage points were observed in the plumbing systems both inside and outside the affected bathrooms. A study by Gormley et al has recommended that transmission through waste-water plumbing systems can be minimized by ensuring that the plumbing network is not defective.²⁴ However, all the above explanations require the virus to be able to be transmitted in aerosols in the environment and also an ability to retain its infectiousness during its presence in drainage/sewage water and pipelines. Some studies now support the plausible aerosol transmission of SARS-CoV-2.³

The role of water in the transmission of respiratory infectious diseases was suggested in 2003, however it mainly emphasized about handwashing.^{25,26} Recently, a novel category of water-related diseases was suggested.²⁷ This transmission was associated with inhalation of droplets or aerosols generated in plumbing systems (e.g. *Legionella*). The spread of SARS-CoV 2003 via the plumbing route has been reported in sewage aerosols in a 50-storey residential building, Amoy Gardens, in Hong Kong which affected residents of the rooms vertically below each other using bathrooms inter-connected via the implicated plumbing system and controlled experiments in a full-scale plumbing test-rig.^{20-23,28} Similar phenomenon has been shown by SARS-CoV-2 in COVID-19.²⁴ In the absence of any other explanation for the phenomenon of concentration of cases to one vertical flank in this study, it is recommended that since transmission through waste water plumbing systems via aerosols could be possible in SARS-CoV-2, the presence of such spreading modality cannot be disregarded in COVID-19.

The association observed in the current study is a purely epidemiological association derived by exclusion of all other possible modes of spread which can explain the phenomenon observed in the backdrop of presence of similar phenomenon observed in SARS-CoV 2003. Interconnected wastewater plumbing networks can facilitate exposure to SARS-CoV-2 (or its certain specific strains) within buildings and is of particular concern in high-risk transmission settings such as hospitals and quarantine facilities. The potential for a significant viral load and aerosolisation of the virus within the wastewater plumbing system necessitates consideration of wastewater plumbing systems as a potential transmission pathway for COVID-19.

This study had some limitations. The study reflects a purely epidemiological association and further studies are required to strengthen the current findings by lab confirmation of the presence of SARS-CoV-2, its specific strain and the viral load. Also, since the current study is in a relatively smaller and single setting, hence, similar studies in larger and multiple settings are required to corroborate/confute the epidemiological findings of the current study and its future public health implications.

CONCLUSION

The study shows a strong epidemiological association depicting local spread of SARS-CoV-2 through usage of common bathroom facility as well as bathroom facilities connected by common defective waste-water plumbing system, a phenomenon previously observed in SARS-CoV in 2003. It enhances our understanding of possible uncommon ways of spread of SARS-CoV-2. It has public health implications in quarantine or institutional facilities with COVID-19 positive cases having neglected wastewater plumbing systems. Ideally, single floor quarantine

facilities are recommended with lesser dependency on common bathrooms.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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