

Original Research Article

Disinfection by 1% sodium hypochlorite through cold fogging: an innovative appropriate technology against COVID-19 in public health

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Received: 22 October 2021

Revised: 15 September 2021

Accepted: 09 December 2021

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ABSTRACT

Background: SARS-CoV-2 is an enveloped virus with a fragile outer lipid envelope that makes it more susceptible to disinfectants compared to non-enveloped viruses. In this article, dispensation through cold Fogger was innovated as a measure against aerosol-based transmission of COVID-19 in large, enclosed spaces like hospitals, nursing homes, isolation centers and quarantine facilities.

Methods: Ecological exploratory study, to ours effectiveness of 1% sodium hypochlorite through cold fogging against SARS COV-2 technology. Study setting included medical college in Western Maharashtra and the selected COVID-19 hospitals. The data was collated in MS excel and analysed using IBM SPSS version 23.0.

Results: Average of 2.9 % HCWs got infected in hospitals where this innovation was used to disinfect, as compared to infections rates of 21.5% and 14.7% in other premier health institutes. There was strong negative correlation between percentage of health care infected and liters of sodium hypochlorite used with $R^2=0.56$. Also, on applying Spearman correlation coefficient there was good negative correlation (-0.8).

Conclusions: This appropriate technology has shown significant reduction in infection, with antecedent benefit of decreased morbidity and mortality of precious trained manpower. It gives much better dis-infection at 07 times less the cost and can be conveniently used for dis-infection against COVID-19 at the very periphery of primary health care delivery done at Sub-centres and PHCs.

Keywords: Disinfection, COVID-19, Appropriate technology, Innovation

INTRODUCTION

World health organization (WHO) declared COVID-19 as public health emergency of international concern (PHEIC) on 30th Jan 2020 and later declared the disease as a pandemic on 11th March 2020. Like other corona viruses, the causative agent of COVID-19, SARS-CoV-2 is an enveloped virus with a fragile outer lipid envelope that makes it more susceptible to disinfectants compared to non-enveloped viruses such as rotavirus, norovirus and poliovirus.¹ The virus can survive in aerosols and according to a recent study published in the New England

journal of medicine, SARS-CoV-2 can persist for 3 hours as aerosols in environment.² But according to latest literature, it can easily be inactivated by several types of physical and chemical disinfection methods.³

Centre of disease control, Atlanta (CDC) defines 'disinfection' as a process that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects. Different types of agents such as alcohols, hydrogen peroxide, benzalkonium or sodium hypochlorite chloride have been used worldwide for disinfection against SARS-CoV-2.

Chemical disinfection in context of COVID-19, can be broadly classified into surface and aerosol based, through handheld sprayers or ULV foggers. Sterisol (A propriety electrolyte solution prepared using purified salts of sodium, magnesium and potassium, buffered to optimum pH), 62-71% ethanol, 1% sodium hypochlorite and 2.5-5% cresol black, have been conclusively proven that these disinfectants can significantly reduce corona virus contamination within few minutes of exposure.⁴ Of these, former is exclusively dispensed as aerosol through ULV fogger and latter three are used as surface disinfectants.

Surface disinfectants though cheap, are not effective in case the pathogen is transmitted through aerosols and can remain suspended in the air and infection gets transmitted through inhalation as is the case of SARS-CoV-2. Disinfection by them is also manpower intensive, requiring painstaking cleaning or wiping of the entire surface which can be potentially contaminated with the pathogen. This is the reason surface disinfectants are not effective in disinfecting large, enclosed spaces, such as hospitals, nursing homes, isolation centers and quarantine facilities.

Aim of this study was to assess effectiveness of disinfection by 1% sodium hypochlorite through cold fogging in COVID-19 pandemic.

METHODS

Study type

This study was ecological study.

Study place

Study was conducted in a medical college of Western Maharashtra. Secondary data was obtained from SVBP COVID hospital, Delhi PM cares COVID hospital, Patna, PM cares COVID hospital, Muzaffarpur, AIIMS, New Delhi, Lok Nayak Jai Prakash COVID hospital, Delhi.

Ethical approval

This study was obtained from Institutional Committee, Armed Forces Medical College, Pune.

Study period

Study conducted from 1 April to 15 Dec 2020.

Inclusion and exclusion criteria

Dedicated COVID hospitals were included across the country using 1% sodium hypochlorite as a disinfection method. Hospitals dedicated for COVID with no authentic information about disinfectant used were excluded.

Sampling technique

Hospitals dedicated for COVID-19 were selected as per availability of authentic data on methods of disinfection used.

Statistical analysis

The data was collated in MS excel and analysed using IBM statistical package for social sciences (SPSS) version 23.0. The categorical variables were summarized using frequency and proportions, while spearman correlation coefficient test was used to determine the association between the study variables.

Sample size

A total of 6 health care institutes dedicated for COVID care were included in the study.

RESULTS

Table 1 describe in detail the various disinfectants used, their target organism, mechanism of action, advantages, and dis-advantages, including commercially available products. Table 2 and 3 gives comparison of various chemicals being used in disinfection against SARS-CoV-2 including cost per liter and quantity of 1% sodium hypochlorite used (till end of first wave of COVID-19) in a medical college in Western Maharashtra and the study hospitals. Average of 2.9 % HCWs got infected in hospitals where the innovation was used to disinfect, as compared to infections rates of 21.5% and 14.7% in other premier health institutes. There was a strong negative correlation between percentage of health care infected and liters of sodium hypochlorite used with $R^2=0.56$. Also, on applying Spearman correlation coefficient there was good negative correlation (-0.8). The innovation of dispensing 1% sodium hypochlorite through cold fogger to disinfect large, enclosed spaces like hospitals, nursing homes, isolation centers and quarantine facilities was found in the study to be both efficacious and cost-effective.

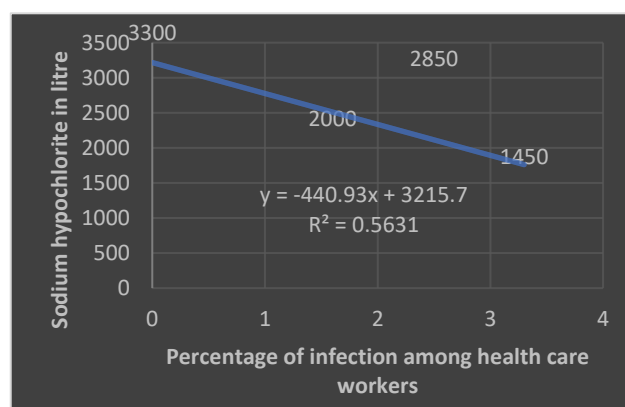


Figure 1: Relationship between amount of 1% sodium hypochlorite used and percentage of infection among HCWs.

Table 1: Disinfectants effective in COVID-19 pandemic.

Name of the disinfectant	Use	Principal of action	Advantages	Disadvantages	Commercially available product
70% isopropyl alcohol solution	Disinfecting instruments and skin	-Changes protein structure of microorganism. -Presence of water assists with killing action	Inexpensive	-50% solution not very effective -Not active when organic matter present. -Not active against certain types of viruses. -Evaporates quickly	Sterillium
Chlorine Compounds	-Spills of human body fluids -Good bactericidal and fungicidal, sporicidal. -Good at >1000 ppm sodium hypochlorite	-Free available chlorine combines with contents within microorganism and reaction byproducts cause its death. -Need 500 to 5000 ppm for action -Depends upon release of hypochlorous acid.	-Kills hardy viruses (e.g., hepatitis) -Kills a wide range of organisms -Inexpensive and penetrates well -Relatively quick microbial kill	-Corrodes metals such as stainless aluminum -Organics may reduce activity -Increase in alkalinity decreases bactericidal property -Unpleasant taste and odor	-Bleach solutions (sodium hypochlorite) -Clorox -Cyosan
Glutaraldehyde	-Good bactericidal, fungicidal, Virucidal and sporicidal. -Excellent tuberculocidal	Coagulates cellular proteins	-Non-staining, relatively noncorrosive. -Useable as a sterilant on plastics, rubber, lenses, stainless steel and other items that can't be autoclaved.	-Not stable in solution. -Has to be in alkaline solution. -Inactivated by organic material.	- Calgocide - 14 Cidex - Vespore
Iodophors (Iodine with carrier)	-Disinfecting some semi-critical medical equipment. -Very Good Bactericidal -Excellent fungicidal and virucidal	-Free iodine enters microorganism and binds with cellular components, carrier helps penetrate soil/fat. -Need 30 to 50 ppm. -Acts probably by disorder of protein synthesis due to hindrance and/or blocking of hydrogen bonding.	-Kills broad range of organisms. -Highly reactive. -Low tissue toxicity. -Kills immediately. -Not affected by hard water.	-May stain plastics or corrode metal. -May stain skin/laundry. -Some organic and inorganic substances neutralize effect.	-Bactergen -Hy-Sine -Providone (iodine/betadine)

Table 2: Comparison of various chemicals being used for disinfection against COVID-19.

Chemical name	Available in concentration	Dilution	Cost/ L (Rs.)
Sterigen-C	From 20 L, 400 L can be made	In 400 L solution, 1200 L water can be added	14
10% sodium hypochlorite	10%	1:9 dilution	2
25% cresol black	25%	1:9 dilution	10
Alcohol based hand sanitizer	60-70%	Nil	480

Table 3: 1% sodium hypochlorite used in study hospitals for disinfection by cold fogging (till end of first wave of COVID-19 i.e., 15 Dec 2020).

AFMS hospital	Quantity used (L)
Medical college in Western Maharashtra, India	1450
SVBP COVID hospital, Delhi	4200
PM cares COVID hospital, Patna	3300
PM cares COVID hospital, Muzaffarpur	2850

Table 4: Preparation methods to prepare 1% sodium hypochlorite.

Strength (%)	Bleaching powder to be added (gm)	Volume of water to be added (L)
Stable bleaching powder		
20	50	1
25	40	1
30	33	1
Commercial hypochlorite solution		
5	200 ml	800 ml
10	100 ml	900 ml

Table 5: Status of HCW getting infected in study hospitals and other dedicated COVID hospitals.

COVID facility	No. of HCW infected	Total HCW	% infected
Medical college in Western Maharashtra, India	92	2728	3.3
SVBP COVID hospital, Delhi	14	855	1.6
PM cares COVID hospital, Patna	0	90	0
PM cares COVID hospital, Muzaffarpur	03	120	2.5
AIIMS, New Delhi	645	3000	21.5
Lok Nayak Jai Prakash COVID hospital, Delhi	103	700	14.7

DISCUSSION

Innovation

At the start of the outbreak, space disinfection against infective aerosols in hospital OPDs, wards and high foot fall places within the college and hospital campus was started with sterigen-C. It was a proven disinfectant and before COVID-19 outbreak was used in OTs and dental procedure rooms to sterilize. Lock down was enforced by the govt. to stop transmission of disease from high focus hot spots to general public on 23 March 2020.⁵ Consequent to prolonged lock-down and disruption of supply chain network, supply of sterisol stopped and existing stocks were exhausted soon. The college being a health care facility and part of essential services and increasing foot fall of potentially infective patients, was in urgent need of aerosol-based disinfectant which was safe to inhabitants, effective at par with existing disinfectant being used, had no residual odor/stains, and economical.

Fogging is a new and effective method for disinfection. Fog is a water-vapor in the atmosphere which condenses due to low temperature and forms dense white layer in atmosphere. Fogging is more preferable over spraying of liquids because the particle size of fog (which can be controlled through available equipment) being smaller than of liquid, has more mobility and penetration to deeper surfaces, resulting in proper and effective disinfection.⁶ Fogging machines that rely on dispersion of fine mist of disinfectants in air, provide effective means for disinfecting large spaces, including hospitals, nursing homes, isolation centers and quarantine facilities.⁷

Hypochlorite displays a broad spectrum of antimicrobial activity and WHO recommended use of 0.1% hypochlorite solution for COVID-19 and 0.5% for large blood and body fluid spills (>10 ml), the MoHFW, GoI and NCDC, New Delhi recommended 1% hypochlorite solution as an effective surface disinfectant against the disease, in health care setting.^{8,10} 1% Sodium hypochlorite as brought-out, is extremely effective and readily available chemical; and ULV fogging machine, used for aerosol disinfection in the Department of Community Medicine, was available. Mating of the two was innovated as a fogging method for disinfection.

Preparation

The 1% sodium hypochlorite can be prepared from various strengths of stable bleaching powder (SBP) i.e., 20%, 25% and 30% or from commercially available 5 and 10% bleaching powder solution. Table 4 details preparation methods to prepare 1% sodium hypochlorite solution for dis-infection.

Effectiveness

The effectiveness of sodium hypochlorite in the cleaning and disinfection processes depends on the concentration of available chlorine and the pH of the solution. Hypochlorous acid (HOCl) is a weak acid and dissociates to the hypochlorite ion (OCl^-) and proton (H^+) depending on the solution pH¹¹. In addition to several precautionary steps being taken (social distancing, use of masks, sanitizing hands etc.), spraying disinfectants (NaOCl solution) over several residential, official and commercial buildings, open areas, markets, public road transports, were being undertaken on a regular basis.¹² Innovative appropriate technology in disinfection, has been extensively used at medical college in western Maharashtra and COVID-19 hospitals established at by the Armed Forces Medical Services (AFMS) and Defense Research and Development Organization (DRDO) at New Delhi, Patna and Muzaffarpur. The prevalence percentage of COVID-19 infection among health care workers (HCWs) working at medical college in western Maharashtra and three study hospitals till waning of first wave of COVID-19 was 3.3, 1.6, 0 and 2.5% respectively, with average of 2.9% in all the AFMS health care establishments. In comparison, other exclusive COVID-19 hospitals like AIIMS, New Delhi (21.5%) and Lok Nayak Jai Prakash COVID hospital, Delhi (14.7%) had significantly higher percentage of HCWs infected with disease (Table 5).

Negative correlation was observed between amount of 1% sodium hypochlorite used and percentage of infection among health care workers, with R^2 of 0.56 (Figure 1). Spearman correlation coefficient came out to be -0.8, which signifies good negative correlation, although p value was non-significant (0.2). The data is suggestive that the disinfection and infection control practices, of which 1% sodium hypochlorite through cold fogging contributed a major component were much more efficacious in the study hospitals as compared to any other disinfection strategy employed in other exclusive COVID-19 Hospitals.

Cost benefit analysis

Cost of 1% sodium hypochlorite, if prepared from commercially available sodium hypochlorite (5 or 10%) is Rs 2/L. It will be even less if prepared from bleaching powder. The study hospitals till end of first wave of COVID-19, consumed 11,800 L of this chemical in aerosol disinfection, with total expenditure Rs. 23,600/-. Had propriety chemical been used, instead of 1% sodium hypochlorite, which was in-vogue before this innovation, the expenditure of the chemical would have been Rs. 1,65,200/-, as it costs Rs. 14/ Liter.

Also, the equipment required to prepare propriety chemical is much costlier. The machine itself is Rs. 8,00,000/-, it requires technical manpower to operate and will have to be put in annual maintenance contract for its smooth operation, without breakages. Compared to this, the cold fogger is available of Rs 25,000/- and a lay

person can prepare 1% sodium hypochlorite and operate the fogger, which anyways will be required for sterisol dispensation too.

Therefore, above clearly illustrated that expenditure was significantly reduced with use of 1% sodium hypochlorite in cold /ULV fogging machine and it is a definitive cost benefit strategy compared to other disinfectants.

Limitations

There were some limitations of study, firstly exact information about area for disinfection of different selected hospitals although comparable was not available. Secondly, only few selected hospitals were used, which may be the reason of getting good negative correlation with non-significant p value when assessing relationship between amount of hypochlorite used and percentage of infection among health care workers.

CONCLUSION

The innovation of dispensing 1% sodium hypochlorite through a cold fogger to disinfect large enclosed spaces like hospitals, nursing homes, isolation centers and quarantine facilities is both efficacious and cost-effective. This appropriate technology can be employed both at peripheral primary health care set-ups like Sub-centers and PHCs and large health care institutes dealing with COVID-19 pandemic for effective disinfection which may help cut down transmission of the disease and significantly reduce the expenditure on disinfection chemicals and its antecedent equipment.

Funding: No funding sources

Conflict of interest: None declared

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

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Cite this article as: Gupta A, Kaushik SK, Kapoor S, Sabarwal GS, Bobdey S, Singh K. Disinfection by 1% sodium hypochlorite through cold fogging: an innovative appropriate technology against COVID-19 in public health. *Int J Res Med Sci* 2022;10:141-6.