Short Review

Effectiveness of Non-Pharmacological Interventions in Containment of COVID-19 Pandemic

Running Title: Non-Pharmacological Interventions for Covid-19

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Abstract

Coronavirus disease (COVID-19), a pandemic disease caused by SARS-CoV-2 virus has spread to 213 countries. Globally, the number of total confirmed cases has exceeded 10 million out of which 503 862 are dead. Current information suggests that COVID-19 is transmitted mainly by respiratory droplets and close contact. In the absence of effective vaccine or treatment, non-pharmacological interventions (NPI) remain the mainstay in the fight against COVID-19. However, the effectiveness of these NPIs is less studied and the evidence is evolving gradually. In this regard, we have done a scoping review of various published literature available in the public domain regarding non-pharmacological interventions against COVID-19 and summarized them. These findings shall help the policy makers to know the effects of each control measure and make a crucial decision in figuring out which ones can be safely implemented, altered or removed in our country to fight against this pandemic.

Key words: COVID-19; Mask; Social Distance; Hand Hygiene; Personal Protective Equipment

Introduction

Pneumonia of unknown cause detected in Wuhan, China was first reported to the World Health Organization (WHO) Country Office in China on 31st December, 2019 [1]. On 11th February 2020, WHO announced a name for the new coronavirus disease 'COVID-19' and its aetiological agent as SARS-CoV-2 virus [2]. As on 30th June 2020, 10 185 374 confirmed cases and 503 862 deaths due to COVID-19 were reported across 213 countries, areas or territories [3]. COVID-19 is transmitted mainly by respiratory droplets and close contact [4]. The respiratory droplets are usually generated when an infected person coughs or sneezes and close contact is defined as any person coming within one-meter

distance of a person coughing/ sneezing. Droplets which land on surfaces may remain viable for variable period and can act as a source of transmission [5].

COVID-19 disease is mainly transmitted by symptomatic laboratory confirmed cases and sometimes through pre-symptomatic transmission via infectious droplets or through touching contaminated surfaces [6]. The incubation period for COVID-19 is on average 5-6 days, but can be as long as 14 days [6]. In the absence of effective vaccine or treatment, non-pharmacological interventions (NPI) may prove useful in the fight against COVID-19 [7].

Need for the study

Various guidelines and advisories are being released globally and nationally in this regard. Use of face masks, hand hygiene and social distancing measures have been suggested in many of these guidelines and advisories, there is need to review the evolving evidence, for the effectiveness of these non-pharmacological interventions (NPIs): masking, hand hygiene and social distancing. The findings shall guide further policies and guidelines regarding NPIs.

Methods

We did a scoping review of the published literature from Jan to May 2020, regarding non-pharmacological interventions (NPI) against COVID-19 viz. masking, hand hygiene and social distancing that was available in public domain in English language irrespective of geographical area. The literature search included the databases/search engines (PubMed/ Medline, Google Scholar), WHO, Centre for Disease Control (CDC) and National Institute for Occupational Safety and Health (NIOSH) websites, COVID-19 related guidance documents from US Food and Drug Administration (FDA) website, Advisories regarding COVID-19 from Government of India (GOI) in MOHFW website (India) and Ministry of Labour and Employment (India). We have also reviewed the special editions/ issues on COVID-19 in selected scientific journals/blogs. We used the following keywords while searching in database/ search engines: 'COVID 19', '2019 novel coronavirus disease', 'SARS-CoV-2 infection', '2019 novel coronavirus infection', '2019-nCoV infection' with 'Respiratory Protective Devices', 'Personal Protective Equipment', 'Masks', 'Hand Hygiene', 'Social Distance', 'Reference Standards' using Boolean operators 'AND', 'OR'. The selected documents were reviewed by four public health specialists, an abstract or summary was read, if containing details of any one NPI was included in the review. The findings were described under three interventions viz., mask, hand hygiene and social distancing. Any difference of understanding or interpreting the documents was resolved by discussion and arriving at a consensus.

Results

A) Masking

Masking refers to the wearing of masks over the face covering the nose and mouth. Respiratory virus infections including COVID-19 cause a broad and overlapping spectrum of symptoms collectively referred to as acute respiratory virus illnesses (ARIs). These ARIs are usually mild but sometimes can cause severe disease including death. Coronaviruses, influenza viruses and rhinoviruses transmit from human-to-human through direct or indirect contact with respiratory droplets (>5 μm) and aerosols (≤5 μm). The contagiousness of individuals with coronavirus and influenza virus infections can vary considerably [8].

Masking helps in preventing the spread of infectious droplets from an infected person to other persons. It also prevents the

surface contamination by these droplets. Stronger evidence exists for masking healthcare workers and limited evidence for masking general public [9,10]. Decision to consider masking shall include the purpose (source control or prevention of COVID 19), risk of exposure (population or individual), vulnerability of person/population to develop severe disease/ death, settings in which population live or person work, feasibility (availability and tolerability) and type of mask (medical/ non-medical) [9].

Medical masks are meant for single use only with exceptions during pandemics facing shortage of personal protective equipment (PPE) where reuse or extended use is recommended with cautions. However, before reusing or extending the use of PPEs one must effectively decontaminate the filtering facepiece (FFP)/ filtering facepiece respirators (FFR) using approved methods that reduce the burden of pathogens, preserve the function of the FFP/FFR, and leave no residual hazardous chemicals behind [11,12]. Also extended use is preferred to reuse of respirator [11]. It is better to use combination of interventions rather than masking alone, because even if one intervention fails/ not available then another intervention shall provide protection to the individual and community [13]. [Table 1]

Counterfeit masks

Counterfeit masks/ respirators refers to any products that are marketed/ sold in the market with false information as NIOSH-approved/ any equivalent approvals without actually being approved by any of these approval agencies, thus may not be capable of providing adequate protection against respiratory pathogens to workers. Government of India (GOI) has declared masks and sanitizers' as 'essential commodities' up to June 30, 2020 as per the notification under the Essential Commodities Act [27]. The purchaser of masks shall look into the features of correct exterior markings to avoid falling prey to counterfeit masks. In India one can check for *BIS 9473-2002* standards [17] for FFP/FFR and *BIS 16289: 2014* standards [18] for surgical masks in addition to *NIOSH TC approval number* (can be checked from website URL: https://wwwn.cdc.gov/niosh-cel/) [28]. Additionally, one can check for permission of manufacturer/ seller by the Directorate General Factory Advice Service & Labour Institutes (DGFASLI) under Ministry of Labour & Employment, India, Respirator test certificate from NABL accredited lab and compliance to Good Manufacturing Practice (GMP) certificate.

Summary of Masking

Respirators do not eliminate the risk of contracting disease or infection but reduces the risk of transmission if they are used in conjunction with other infection control measures such as hand hygiene, social (physical) distancing, patient identification, isolation, negative pressure ventilation, and healthcare worker screening [29]. The community which follows masking alone may develop false sense of security, ignoring other essential interventions like hand hygiene practices and physical distancing. These communities may also take away the medical masks away from health care workers who need them most, especially when masks are in short supply. Hence, general public shall continue using cloth face coverings as recommended by CDC and not surgical masks/ N-95 respirators that are critical supplies and need to be reserved for healthcare workers and other medical first responders [10].

B) Hand Hygiene

Hand hygiene refers to any action of hand cleansing and it's a measure of personal hygiene [30]. Hand hygiene is one of the

primary measures in reducing many bacterial and/or viral infections. As per WHO and UNICEF, there are inadequate hand hygiene facilities at home for the majority of the world population and also at healthcare facilities [31].

Coronavirus can be detected in aerosols for up to three hours and on plastic and stainless-steel surfaces for up to three days. These findings emphasize the importance of handwashing and disinfecting frequently touched objects and surfaces [32]. A study conducted in 2009 during the pandemic of influenza (H1N1) found the use of face masks with hand hygiene showed a significant reduction in virus transmission [33]. The efficacy of hand hygiene in reducing transmission of SARS-CoV-2 virus will depend on the primary mode of its transmission: droplets or aerosols. The more likely the virus transmitted by large droplets, the more likely that hand hygiene will reduce transmission [34, 35]. WHO has recommended alcohol-based hand rubs such as those containing ethanol (80% v/v) or isopropanol (75% v/v) as active components, have a marked virucidal effect against SARS-CoV and MERS-CoV [30, 36].

Types of hand hygiene [37]:

- **Social handwashing** - i.e. with soap and water; practiced when the hands are soiled, before starting work, before handling food or leaving for home, and after visiting the toilet, or cleaning sessions (minimum 20 seconds).
- **Hygienic hand-washing** - washing with an antiseptic handwash preparation (or handwashing followed by an alcohol-based antiseptic hand rub); practiced before any procedure involving high-risk patients or an invasive procedure, and after contact with infected patients, contaminated material or equipment (minimum 40-60 seconds).
- **Surgical hand-washing** - practiced before all major surgical procedures, usually a two-minute hand wash using an antiseptic preparation.

Studies showed lack of knowledge, too busy with work, feeling not at risk, having sore/dry hands, peers/other family members not practicing, lack of water supply as some of the most common reasons for poor-compliance to hand hygiene [38-40].

Agents of hand hygiene

The choice of hand-washing product depends on its intended use.

Water - Water is a good solvent for a large number of substances including dirt, organic material and transient microorganisms. Water should be free from physical, chemical and bacteriological contaminants. Frequent cleaning and/or emptying of water storage containers need to be done.

Plain (non-antimicrobial) soap - These are products with minimal antimicrobial activity, are detergent-based containing esterified fatty acids and sodium/potassium hydroxide. However, handwashing with plain soap can remove loosely adherent transient flora for example, handwashing with plain soap and water for 30 seconds reduces counts by 1.8–2.8 log10 [41]. Hand Hygiene with both alcohol-based hand rub and soap with water is highly effective in reducing influenza A virus on human hands [42].

Alcohols– Majority of the alcohol-based agents contain either ethanol, isopropanol or n-propanol, or a combination of two of these products. Alcohol preparations containing at least 60–80% of alcohol is best compared to higher concentrations which are less potent. Ethanol, the most

common alcohol ingredient is most effective against viruses; whereas, the propanol has a better bactericidal [43, 44]. These are rapidly germicidal on skin but have no appreciable persistent (residual) activity but on addition of chlorhexidine or quaternary ammonium compounds their persistent activity is increased [42,45]. A synergistic combination of a humectant (glycerine) and preservatives can prolong the activity against transient pathogens [46]. There are many factors affecting the efficiency of hand hygiene like the type, concentration, contact time, volume and dryness of the palms at the time of alcohol product application. As alcohol isn't effective when the hands are dirty/visibly contaminated as it's not a good cleansing agent [47, 48].

A study on the efficacy of different alcohol hand rubs and routine hand wash among healthcare workers revealed that the median percentage reductions in hand contamination with alcohol-based liquid/gel compared to soap & water [49]. Many studies have demonstrated that having bedside alcohol-based solutions available increased compliance with hand hygiene among Health Care Workers [50-53].

Alcohols are flammable. As the flashpoint of alcohol is 21°C - 24°C, it should be stored away from high temperatures or flames and after application, hands should be rubbed together until all the alcohol has evaporated [54, 55].

Chlorhexidine– Majority of hand sanitizers has Chlorhexidine gluconate. Aqueous or detergent formulations containing 0.5%, 0.75%, or 1% chlorhexidine are more effective than plain soap but are less effective than antiseptic detergent preparations containing 4% chlorhexidine gluconate [56, 57]. Chlorhexidine has significant residual activity. Hence, it is mixed in low concentrations (0.5–1%) with alcohol-based preparations to increase their residual action. Care must be taken to avoid contact with the eyes as these preparations can cause conjunctivitis or serious corneal damage.

Iodine and iodophors – Skin irritation and/or discoloration have resulted in iodophors replacing iodine in the majority of the antiseptic preparations. It's the amount of 'free iodine' which determines the level of antimicrobial activity. A10% povidone-iodine formulations have1% available iodine and 1ppm free iodine [58]. Atmospheric temperature, pH, time exposed, total available iodine, the amount and type of organic and/or inorganic compounds present (e.g., alcohols, detergents) affect the antimicrobial activity of iodophors. Most of the iodophor preparations containing 7.5–10% povidone-iodine are used in hand hygiene preparations. Any formulations with lesser concentrations could also be used as dilution results in increase free iodine availability. As the number of free iodine increases, however, the degree of skin irritation also increases [59].

Non-Alcohol-Based Hand Sanitizers – Most of the non-alcohol sanitizers contain a quaternary ammonium compound, Benzalkonium Chloride. It's non-flammability and in lower concentration it's relatively non-toxic. Usually, these solutions are often available in water-based foam preparations and are much easier to use and after drying also will provide protection. They pose much less of a threat in cases of accidental ingestion or as a potential fire hazard and are non-damaging to surfaces [60].

Hand drying - Hand drying is an essential step as wet hands lead to transmission of microorganisms. Hot air dryers and Paper/cloth towels are some of the commonly used methods.

Summary of Hand Hygiene

The choice of agent in hand hygiene is based on whether it is important to reduce and maintain minimal counts of colonizing flora as well as remove transient microorganisms. Agents selected for hand hygiene should have good bacterial activity against a range of microorganisms and minimal toxicity to the skin. We need to analyze the cost of using either effective/safe/acceptable hand-washing solutions and compare with human and economic costs in cross-infection and decide for ourselves the importance of hand hygiene.

C) Social distancing

Social distancing means keeping space between oneself and other people, outside home [61]. It's better to be termed as 'physical distancing'. To practice social/ physical distancing, distance between the people should be 6 feet (2 meters) or at least 3 feet (1meter), gathering in groups and crowded places must be avoided. Rationale of social distancing in the current situation slows transmission and reduces the growth rate in case numbers. This preventive approach aims to lessen the pressure on health care workers and hospital facilities. Social distancing measures: The Government of India has taken various measures to avoid mass gathering like closure of all educational establishments (schools, universities etc.), gyms, museums, cultural and social centers, swimming pools, restaurants and theatres, postponing of exams and encouraged the private sector to allow employees to work from home wherever feasible. When these measures found inadequate in controlling the spread of COVID19 and people were not complying with these measures, the government came up with a 21 days complete lockdown throughout the nation with provision for only essential services to work. Lockdown was further extended for 2 more weeks. Effectiveness of social distancing: School closures: Mathematical modeling has shown that transmission of an outbreak may be delayed by closing schools. However, effectiveness depends on the contacts children maintain outside of school necessitating prolonged closures. These factors could result in social and economic disruption [62].

Modeling and simulation studies based on U.S. data on workplace closures suggest that if 10% of workplaces affected are closed, the overall transmission rate is around 11.9% and the epidemic peak time is slightly delayed. Similarly, if 33% of workplaces which are affected are closed, the attack rate will decrease to 4.9%, and the peak time is delayed by one week [63]. Cancellation of mass gatherings like sports events, films or musical shows, evidence suggesting that mass gatherings increasing infectious disease transmission is inconclusive [64, 65]. Even though mathematical models have shown the impact of various social distancing strategies in controlling the outbreak, swiftness and robustness in implementing these strategies determines the impact, which remains a challenge to the government in balancing what needs to be done with what is feasible, and this will vary between countries. In this aspect India has fared well so far as evident by the prompt measures taken, particularly social distancing and the lockdown at the beginning of outbreak, that have slowed down the spread of the COVID-19 in a densely populated country.

Social distancing with 90% of adoption and complete closure of non-essential gathering are valid strategies for mitigating the outbreak. However, once the restrictions on social distancing are lifted the risk of having a second outbreak is high. To prevent this situation, active strategies such as massive testing, remote symptoms monitoring, isolation of new cases and contact tracing need to be

implemented [66]. The success of current government-led outbreak control measures depends on public cooperation through exercising good hygiene, prevention of infection transmission in shared spaces, and adequate education to understand when symptoms might be indicative of a potential COVID-19 infection. Public complicity is particularly crucial for older individuals (>60 years), individuals who are immune-compromised, and people with co morbidities who are at high risk of severe disease [67, 68]

Summary of Social Distancing

Social (physical) distancing slows transmission and reduces the growth rate in case numbers but its impact varies depending on the strategies of government in controlling the outbreak, swiftness and robustness in implementing these strategies and the compliance to it by public.

Limitations of the study: The literature searched included published literature and guidelines/ advisories in English language and available in public domain.

Conclusion

The non-pharmacological interventions viz. masking, hand hygiene and social distancing are effective in preventing the transmission of COVID-19 and slowing down its transmission in the country. These interventions are to be utilized in conjunction with each other rather than in isolation.

Recommendations

The findings of this study shall help policy makers for knowing the effects of each intervention/control measure to figure out which ones can be safely implemented, altered or removed in our country to fight against this COVID-19 pandemic.

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Nil

Conflicts of interest

There are no conflicts of interest.

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None

Table 1: Comparison of various types of masks used in different settings.

Particulars	Type of masks		
	Respirator/FFP/FFR	Medical Mask (surgical/procedure mask)	Non-medical Mask (community' masks)

Description	It is respiratory protective device designed to protect the wearer from exposure to airborne contaminants (infectious agents present in small and large particle droplets) and is classified as personal protective equipment (PPE) [14]. [Figure 1]	It is a loose-fitting disposable device that acts as physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment [15] [Figure 1].	It is made from cloth/ other textile materials/ paper. It can be self-made or commercially made [Figure 1].
Seal Check & Fit Test	Achieve a very close facial fit as the edges of the respirator are designed to form a seal around the nose and mouth.	The edges of the mask are not designed to form a seal around the mouth and nose.	The edges of the mask are not designed to form a seal around the mouth and nose.
Recommended Use	Healthcare workers -to protect themselves, especially during aerosol-generating procedures. Respirators with valves do not prevent the release of exhaled respiratory particles from the wearer into the environment, hence not recommended for the use as a means of source control [16].	Healthcare workers -designed to protect the wearer from large respiratory droplets and splashes to the mouth and the nose and also helps to reduce and/or control at the source the spread of large respiratory droplets from the person wearing the face mask [14].	General Public - use simple cloth face coverings when in a public setting to slow the spread of the virus, since this will help in preventing the transmission of the virus from wearer to others.
Certification/ Standards	**<u>International Standards</u>** **American standard** managed by NIOSH (part of CDC) -*N95/N99/N100* **European standard** EN standard 149:2001 and EN standard 143 Covers*P1/P2/P3* ratings for *FFP* [16]. **<u>Indian Standards</u>**	**Indian Standards** Bureau of Indian Standard, *BIS 16289: 2014* specifies the performance requirements and test methods of surgical facemasks [18] *Classes:* Class 1, Class 2 and Class 3 as per Bureau of Indian Standard and based on	They are not standardized and are not intended for use by healthcare workers professionals, those working with or in contact with COVID 19 patients or are patients themselves. They are intended to be used by the general public only especially people living in densely populated areas across India.

	Bureau of Indian Standard, *BIS 9473-2002* standards specify respirators shall meet requirements of Breathing resistance, Penetration of filter material, Flammability, Leakage, Vision, Head harness, CO_2 inhalation, Clogging, Compatibility with Skin [17]	following criteria: performance requirement such as Bacterial filtration efficiency, Differential Pressure, Splash Resistance, Sub micron particulate filtration efficiency.	
Effectiveness	Very effective in filtering particles with size of approx. 0.3microns. Respirator Standard Filter Capacity depends on the type [19,20]. FFP1 & P1 ~ 80% FFP2 & P2 ~ 94% N95 ~ 95% N99 & FFP3~ 99% P3 ~ 99.95% N100 ~ 99.97% The European equivalents to N95 are FFP2 / P2.	Effective in reducing coronavirus detection and viral copies in large respiratory droplets and in aerosols [8]. However, they may not filter/ block very small particles in the air and do not provide complete protection against germs / contaminants because of the loose fit between the surface of the mask and face [15].	Non-medical face masks are less effective compared to medical masks as a means for source control [21]. There are no established standards available for non-medical face masks.
Structure	*Material:* of non-woven fabric, often made from polypropylene. *Layers: Multiple layers* [22] 1 Outward layer - created using spun bonding. 1 Pre-filtration layer -	*Material:* of non-woven fabric, often made from polypropylene. *Layers:* 3-layers [23] *1 Outer layer:* Waterproof against droplet spray (usually coloured) *1 Middle layer:* Particle	*Material:* cotton cloth *Layers:* Multiple layers preferably 3 layers [24]. Stitched with pleats and ear loops or ties.

	needled nonwoven 1 Filtration layer - High efficiency melt blown electret/ polarized non-woven material 1 Pre-filtration layer - needled nonwoven 1 Inward layer - created using spun bonding.	filter to block pathogens *1 Inner layer:* Water absorbent to absorb breathed out moisture.	
Disposal	Used respirator should be segregated/ discarded safely in a yellow bag in a yellow colour biomedical waste bin with a lid. One must wash hands after handling the used respirator [25].	Used medical mask should be safely discarded in a yellow bag in yellow colour biomedical waste bin with a lid. One must wash hands after handling the used respirator [25].	Waste masks in general households should be kept in paper bag for a minimum of 72 hours prior to disposal of the same as dry general solid waste after cutting the same to prevent reuse. Wash your hands after handling the used mask [25].
Re-use*	Not recommended routinely. Allowed only during crisis and shortage of PPE. Ultraviolet germicidal irradiation, vaporous hydrogen peroxide and moist heat are the most promising decontamination methods. However, discard if used during aerosol generating procedures, respirators contaminated with blood, respiratory or nasal secretions, or other bodily fluids from patients [11].	Surgical masks are not recommended to be used more than once. If your surgical mask is damaged or soiled, or if breathing through the mask becomes difficult (increased resistance), you should remove the face mask, discard it safely, and replace it with a new one [15].	One of the advantages of nonmedical face masks made of cloth or other textiles is that can be washed and reused and they can be made easily. However, one must thoroughly wash and clean the face cover before wearing it again. Never share the face cover [26].
Alternatives	Alternatives to N95 respirators - other classes of filtering facepiece (FFP) respirators, elastomeric half-mask and full	Face shield, Physical barriers and physical distancing (>1m) with patient.	If no mask, cover your mouth and nose with elbow while coughing and sneezing.

	facepiece air purifying respirators, powered air purifying respirators.		

Note: ***Reuse*** means using the same respirator for multiple encounters with patients, removing it/ doffing after each encounter, storing it in between the encounters and to put on/ donning again before encounter with a patient. ***Extended use*** means wearing the same respirator for encounters with several patients, without removing the respirator in between patients encounters [11].

Figure 1: Representation Images of different types of masks

Note: From above below – Respirator (N95), Surgical Mask (triple layer), Fabric Mask (Cotton mask)

Table 3: WHO suggested composition of alcohol-based formulations (1000 ml) for in-house/local production [30]

Details	***Formulation I***	***Formulation II***
Strength of Preparation	To produce final concentrations of ethanol 80% v/v, glycerol 1.45% v/v, hydrogen peroxide 0.125% v/v.	To produce final concentrations of isopropyl alcohol 75% v/v, glycerol 1.45% v/v, hydrogen peroxide 0.125% v/v:
Ingredients for	Ethanol 96% v/v, 833.3 ml	Isopropyl alcohol (with a purity of 99.8%), 751.5 ml

Preparation	Hydrogen peroxide 3%, 41.7 ml	Hydrogen peroxide 3%, 41.7 ml
	Glycerol 98% ,14.5 ml	Glycerol 98%, 14.5 ml
Preparation Method	To the above ingredients, top up to 1000 ml with distilled or boiled and cooled water and shake the flask gently to mix the content.	To the above ingredients, top up to 1000 ml with distilled or boiled and cooled water and shake the flask gently to mix the content.

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