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Original article

Cost-effectiveness of surgical mask, N-95 respirator, hand-hygiene and surgical mask with hand hygiene in the prevention of COVID-19: Cost effectiveness analysis from Indian context

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ABSTRACT

Introduction: In the absence of specific treatment, preventive strategies are of paramount importance in management of coronavirus disease 2019(COVID-19) pandemic. We estimated cost-effectiveness of non-pharmacological interventions such as hand-hygiene, surgical-mask N-95 respirators and surgical mask in general population.

Methods: We performed a decision tree and markov-model based economic evaluation. We estimated total costs and outcomes from public payer's perspective, based on information available through systematic literature search on relative intervention effect during early pandemic phase. We estimated outcomes as number COVID-19 prevented and Quality Adjusted life year (QALY) over one-year time-horizon with one-day cycle-length. Incremental cost effectiveness ratios (ICER) was calculated multiple sensitivity analyses were applied to assess parameter uncertainty.

Results: Use of surgical mask with hand hygiene, fit tested N-95 respirator, surgical-mask, non-fit tested N-95 and hand-hygiene interventions prevented additional 1139, 1124, 1121, 1043 and 975 COVID-19 cases per-million as compared to using none. Additional costs incurred (in billion) were ₹29.78 ($0.40), ₹148.09 ($1.99), ₹72.51 ($0.98), ₹26.84 ($0.36) and ₹2.48 ($0.03) as well as additional QALYs gained were 357.4, 353.01, 327.95, 351.52 and 307.04 for surgical mask with hand hygiene, fit-tested N-95, non-fit-tested N-95, surgical mask and hand-hygiene respectively. ICERs with surgical with hand hygiene, hand-hygiene alone, surgical-mask alone, N-95 respirator fit and non-fit test were 83.32($1.12), 8.07($0.11), 76.36($1.03), 419.51($5.65) and 221.10 ($2.98) million ₹ ($)/QALY respectively. Results were robust on uncertainty analysis.

Discussion: Among the non-pharmacological interventions to be considered for preventing spread of COVID-19, hand hygiene was cost-effective and avoidance of use of surgical masks and respirators by the general public could save resources.

1. Introduction

Recently the world has experienced coronaviruses related outbreaks namely severe respiratory distress syndrome (SARS), middle east respiratory syndrome (MERS) since 2003 and currently by a novel coronavirus (SARS-CoV-2) leading to Coronavirus disease 2019 (COVID-19) since December 2, 019.[1] COVID-19 was initially identified as an outbreak of viral pneumonia in the Wuhan province of China.[2] COVID-19 spread across the globe and is currently turned into a pandemic situation.[3,4] Existing evidence suggests that SARS-CoV-2 spreads person-to-person through respiratory droplets (coughing or sneezing), fomites (viable virus on surfaces), and contacts.[5] All COVID–19 initially can be asymptomatic and later presents with respiratory symptoms, fever, cough, sore throat, shortness of breath, headache as well as diarrhea.[6] These symptoms usually appear 2–14 days after exposure.[5]

The countries are struggling to fight the spread of the pandemic through many strategies since there is no vaccine yet available for

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surgical mask with hand hygiene, hand-hygiene alone, surgical-mask alone, N-95 respirator fit tested and non-fit test were 83.32 ($1.12), 8.07 ($0.11), 76.36 ($1.03), 419.51 ($5.65), and 221.10 ($2.98) million ₹ ($)/QALY respectively. The ICER shows that from the health system perspective, implementation of non-pharmacological interventions such as hand hygiene, surgical mask, N-95 respirator (fit tested and non-fit tested), and surgical mask with hand hygiene among the general population for the prevention of COVID-19 was not cost-effective in India as they exceeded the three times cost-effectiveness threshold of ₹ 1,42,719 ($1921). However, use of a surgical mask with hand hygiene, fit-tested N-95 respirator, surgical-mask, non-fit tested N-95, and hand-hygiene interventions prevented 1139, 1124, 1121, 1043, and 975 COVID-19 cases per 1 million population respectively as compared to using no NPIs (Table 2).

3.2. One-way sensitivity analysis

In the Markov model for the surgical mask, among all input parameters varied, the ICER results were most sensitive to variations in the transitional probabilities (quarantine to normal, quarantine to mild, normal to quarantine, staying in quarantine), utilities (quarantine and normal) and cost (surgical mask) (Fig. 3a). On the other hand, the model estimates were negligibly sensitive with respect to variations in the odds of getting infected with wearing a mask, transitional probabilities (severe to critical, mild to severe, mild to recovery and staying in severe), and utility (severe) and costs (severe, testing, quarantine) With respect to the Markov model for respirator (fit-tested), the ICER results were most sensitive to variations in the utility of normal, transitional probabilities (severe to critical, severe to recovery and severe to death) The model estimates were negligibly sensitive with respect to variations in the transitional probabilities (severe to critical, mild to severe, mild to recovery and staying in severe) and costs (quarantine, isolation, testing, mild and severe) (Fig. 3b). Whereas in the model for respirator (non-fit tested), the ICER results were highly sensitive to variations in utility of normal, transitional probabilities (normal to quarantine and quarantine to mild) and negligibly sensitive to variations in the transitional probabilities (severe to critical, severe to recovery and severe to death) and costs (per out-patient, isolation, mild, severe, testing and quarantine) (Fig. 3c). In the Markov model for hand hygiene, ICER results were highly sensitive to variations in utility of normal, transitional probabilities (normal to quarantine and quarantine to mild), moderately sensitive to variations in transitional probability of staying severe and costs (quarantine and testing) whereas negligibly sensitive to variations in costs (per out-patient, isolation, mild and severe) and transitional probabilities (critical to death, staying at mild and mild to severe) (Fig. 3d). Finally, in the Markov for surgical mask with hand hygiene, ICER results were highly sensitive to variations in the utility of quarantine, transitional probabilities (quarantine to normal and mild to recovery) and odds of not getting infected with surgical mask plus hand hygiene and negligibly sensitive to variation in the cost of isolation (Fig. 3e). One-way sensitivity analysis results of total infected cases and cases prevented for each of the interventions has been given as supplementary figures (Supp. Figs. S1 & S2).

3.3. Probabilistic sensitivity analysis

According to the Monte Carlo simulation with 1000 simulations (Fig. 4) majority of ICER plots appear at the upper-right quadrant of the plane extending to form an ellipsoid shape, which implies that ICERs were not cost-effective and a positive correlation between incremental cost and incremental outcomes.

4. Discussion

In the absence of published studies on the cost-effectiveness of preventive measures of surgical mask with hand hygiene, hand hygiene alone, use of surgical masks alone, and N-95 respirator for COVID-19 as compared to no intervention, we evaluated the same in the Indian context, probably the first of its kind. We observed that none of these interventions were cost-effective, considering the WHO based willingness to pay threshold. Among the interventions, hand hygiene appeared to be less expensive as compared to other interventions but with similar effectiveness compared to the other expensive options. However, the use of surgical mask with hand hygiene prevented the maximum number of deaths due to COVID-19 in our model.

Though the interventions that have been considered in this study have shown clinical effectiveness as evidenced by additional QALYs gained and the number of cases prevented with the use of these interventions, none of them were cost-effective probably due to higher costs of interventions as it is provided to all the population and borne by the public payer with relatively lower effectiveness of the intervention in preventing the infection. With the enhanced production of surgical and N95 masks by Indian manufacturers, it is now possible to get these interventions at a much lower cost\. However even with ten times lower cost of N95 masks, it is still not cost-effective probably due to lower effectiveness. In order to reserve the resources (surgical and N95 masks) for front line health care workers, CDC recommends the use of cloth face masks among general public.[30] Although the efficacy of cloth masks compared to medical grade masks is minimal, its efficacy is relatively high with multiple layers of hybrid fabrics and encouraged to be used in crowded indoor, and outdoor public spaces involving physical proximity to prevent the spread of SARS-CoV-2 infection.[31,32]

In our study, hand hygiene is predicted to effectively prevent COVID-19 in the population and is less expensive compared to the use of surgical masks/respirators though not cost-effective. Our findings are supported by previous studies that denote washing hands for at least 20 s with soap and water or using a hand sanitizer which contains 60% alcohol[5] ensures proper hand hygiene which can potentially degrade most of the coronaviruses including SARS-CoV, MERS-CoV, and SARS-CoV-2 and has shown significant effect in reducing the surface transmission of these

Table 2
Cost-effectiveness results.

	Mask with hand hygiene	Hand hygiene	Mask	Respirator (fit-tested)	Respirator (non-fit tested)	No Intervention
Total Cost (₹ in billions)	30.32 ($0.4)	3.02 ($0.04)	27.38 ($0.36)	148.63 ($2.0)	73.05 ($0.98)	0.54 ($0.007)
Total QALY	9,99,989	9,99,938	9,99,983	9,99,985	9,99,959	9,99,632
Incremental Cost [a] (₹ in Billions)	29.78 ($0.40)	2.48 ($0.03)	26.84 ($0.36)	148.09 ($1.99)	72.51 ($0.98)	–
Incremental QALY[a]	357.4	307.04	351.52	353.01	327.95	–
ICER[a] (₹ Millions/QALY)	83.32 ($1.12)	8.07 ($0.11)	76.36 ($1.03)	419.51 ($5.65)	221.10 ($2.98)	–
ICER[b] (₹ in Billions/QALY)	0.54 ($0.01)	–	0.55 ($0.01)	3.17 ($0.04)	3.35 ($0.05)	–
Total Cases (per Million)	36.15	199.99	54.10	50.39	131.94	1175.19
Cases prevented[a] (per Million)	1139	975	1121	1125	1043	–
Cases prevented[b](per Million population)	164	–	146	150	68	–
Total Deaths (per Million population)	2.27	12.6	3.40	3.17	8.31	74.04

[a] Compared to no intervention.
[b] Compared to Hand hygiene.