Unmasking COVID-19: Comparative Analysis of Mask Usage and Environmental Impact in Asia

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Introduction

The COVID-19 pandemic has significantly increased the demand for face masks. Understanding usage patterns, influencing factors, and assessing environmental impacts across areas is vital for creating sustainable mask usage policies. This study examines mask usage in six Asian areas across distinct pandemic phases (pre-COVID-19, COVID-19, and the new normal). It evaluates the environmental impact of disposable surgical masks and cloth masks, covering carbon footprints, water footprints, solid waste, and microplastic pollution. The research results indicate that during the COVID-19 period, there was a sharp increase in mask usage, followed by a decrease in the new normal phase, although it remained higher than the pre-pandemic levels. Furthermore, age and gender commonly influence the usage of disposable surgical face masks, with educational level having the most prominent impact on cloth face mask usage, followed by age and income. Disposable surgical masks have a greater environmental impact, but replacing them with cloth masks may reduce carbon emissions, waste, and microplastic pollution. However, it might increase water resource usage. Based on these findings, the study provides comprehensive policy recommendations related to mask usage and disposal.

Aim

(1) Understanding the usage patterns of disposable surgical face masks and cloth face masks in different phases of COVID-19.
(2) Analyze the influence of personal characteristics on the use of two types of masks.
(3) Estimate the environmental impact assessment of the two types of masks.

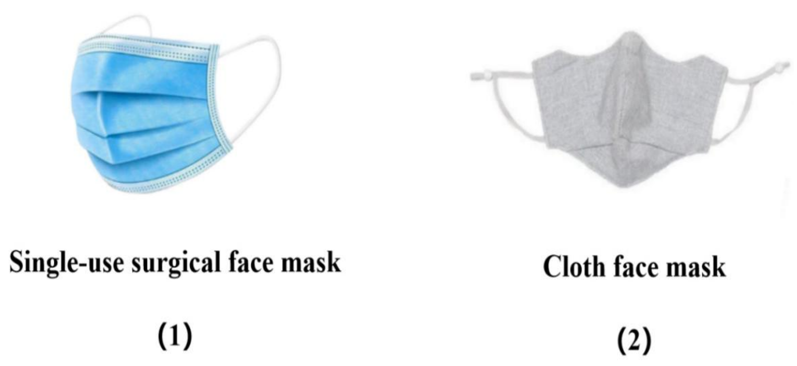
Materials and Methods

Data: This study leverages survey data encompassing mask usage covered six areas across five countries: Shanghai (SH) and Harbin (HRB) in China, the Philippines (PH), Hanoi (HAN) in Vietnam, Phnom Penh (PNH) in Cambodia, and Depok (DP) in Indonesia, with 1870 questionnaires collected.

Methodology: Two-factor ANOVA, T-test, and Poisson regression analysis.

Questionnaire: The questionnaire mainly consists of two parts. The first part covers the basic characteristics of the respondents, including gender, age, area, education level, and monthly household income, among others. The second part focuses on mask usage, including the quantities of sigle-use surgical face masks and cloth face masks used during the periods before COVID-19, during COVID-19, and in the new normal.

Results



The results of respondent characteristics in the survey questionnaire are presented in Figure 1, while mask usage is depicted in Figure 2 and Figure 3.

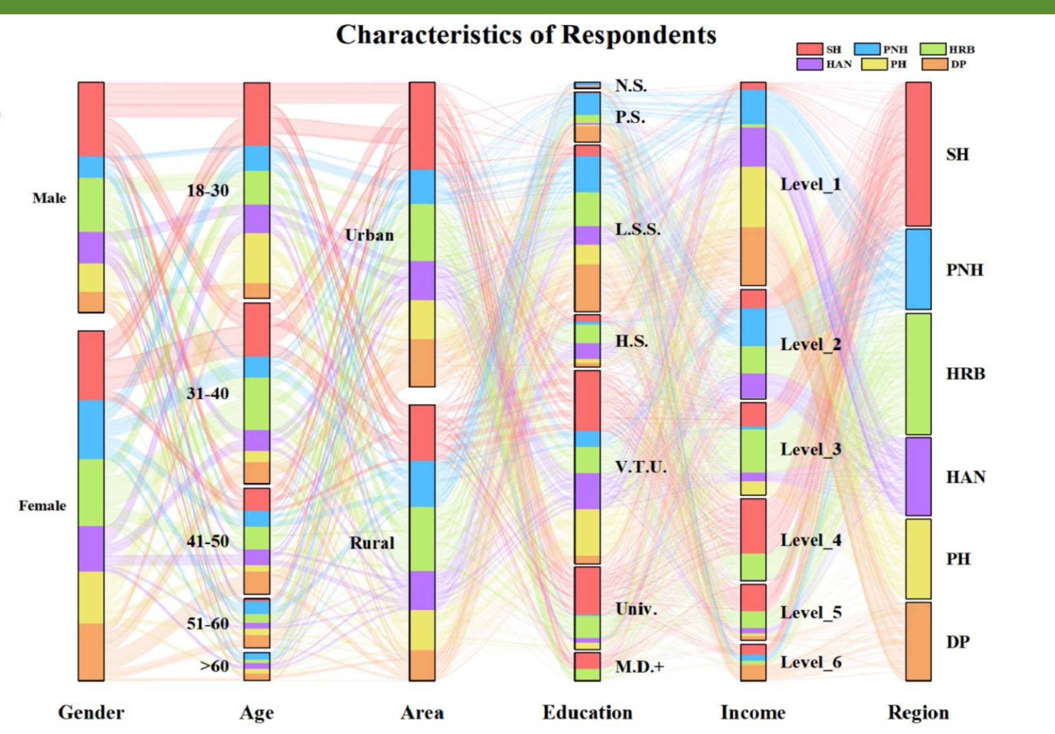


Figure 1. Characteristics of respondents.
(SH-Shanghai; PNH-Phnom Penh; HRB-Harbin; HAN-Hanoi; PH-Philippines; DP-Depok; N.S.-No schooling; P.S.-Primary school; L.S.S.-Lower secondary school; H.S.-High school; V.T.U.-Vocational or technical university; Univ.-University; M.D.+-Master's degree or higher)

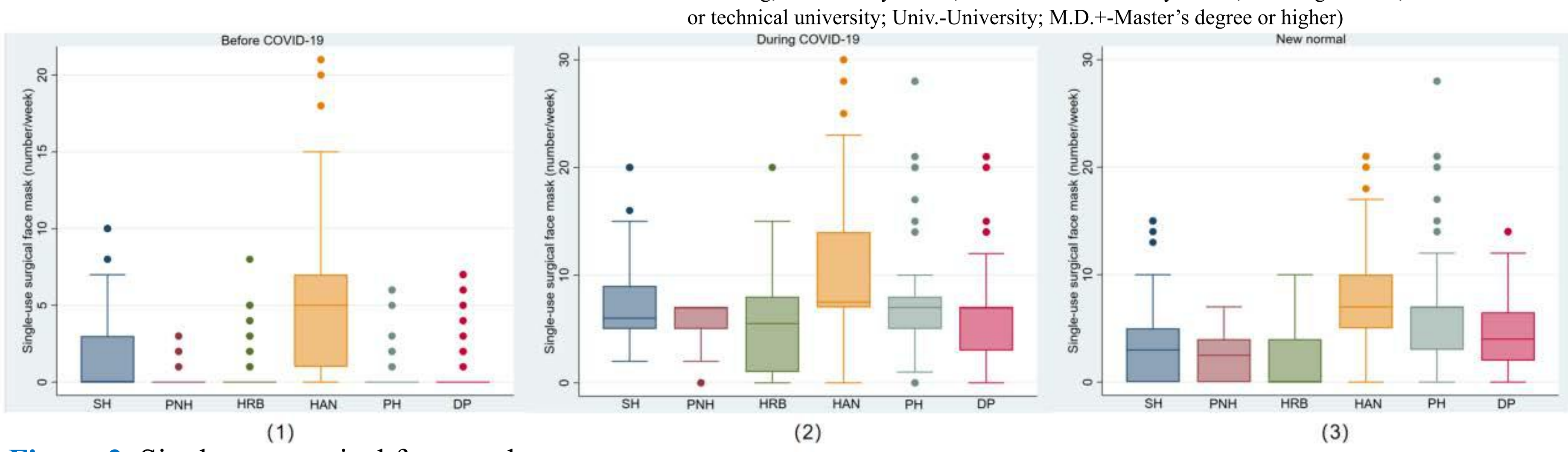


Figure 2. Single-use surgical face masks usage.

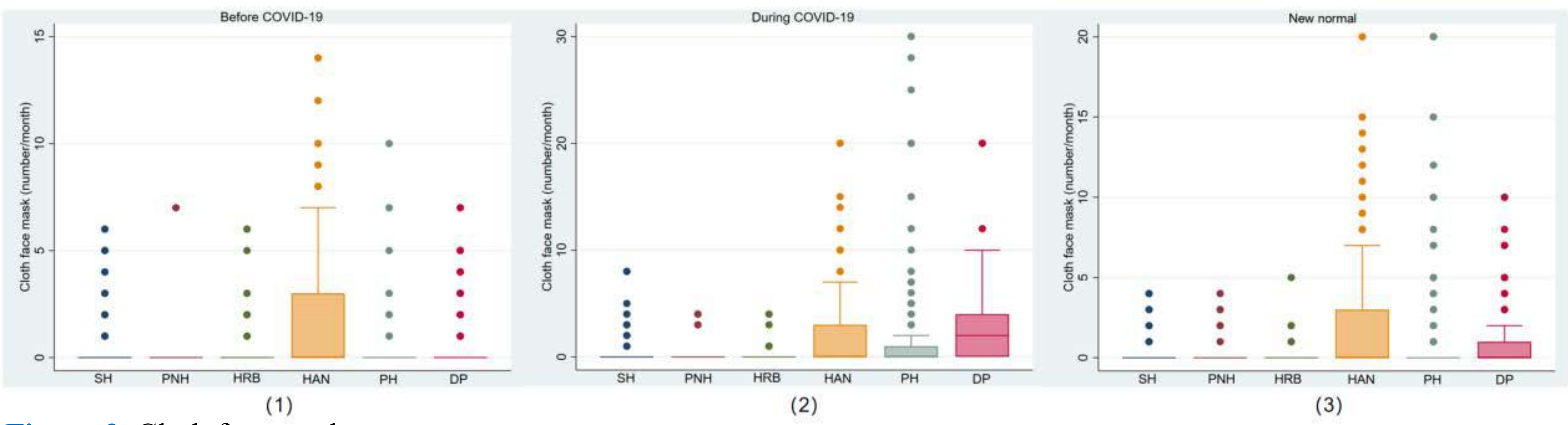


Figure 3. Cloth face masks usage.

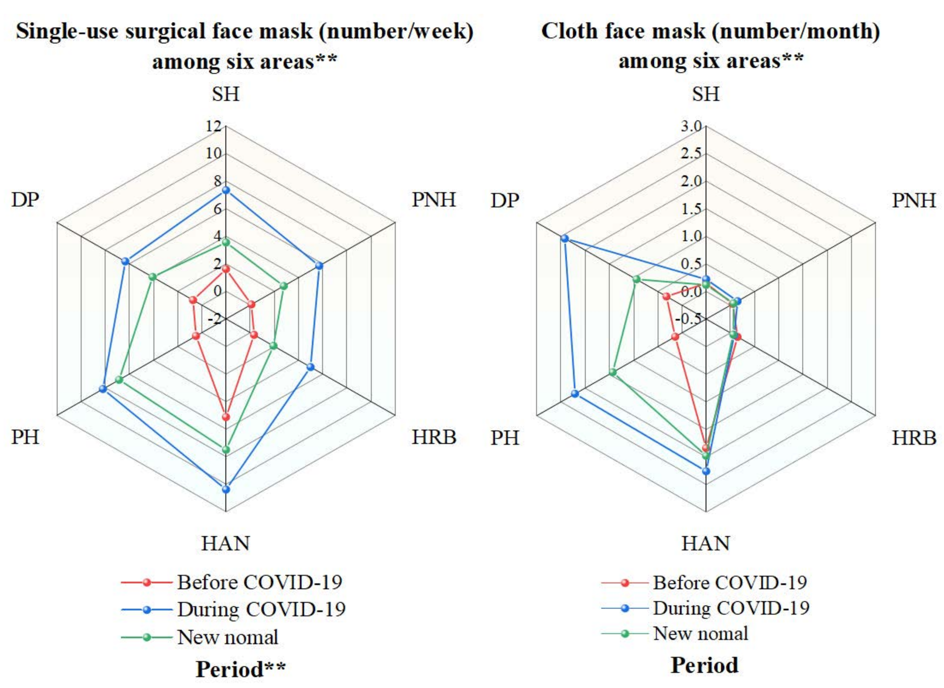


Figure 4. Average number of mask usage in different areas.
** indicates significance at the 99% confidence.

The two-way ANOVA results provide valuable insights into face mask usage (Figure 4). There are significant differences in the usage of single-use surgical face masks and cloth face masks among areas, with notable disparities in the usage of single-use surgical face masks during various phases of COVID-19 but no significant differences observed in cloth face mask usage. This might be attributed to the better protective properties of single-use surgical face masks compared to cloth face masks against COVID-19.

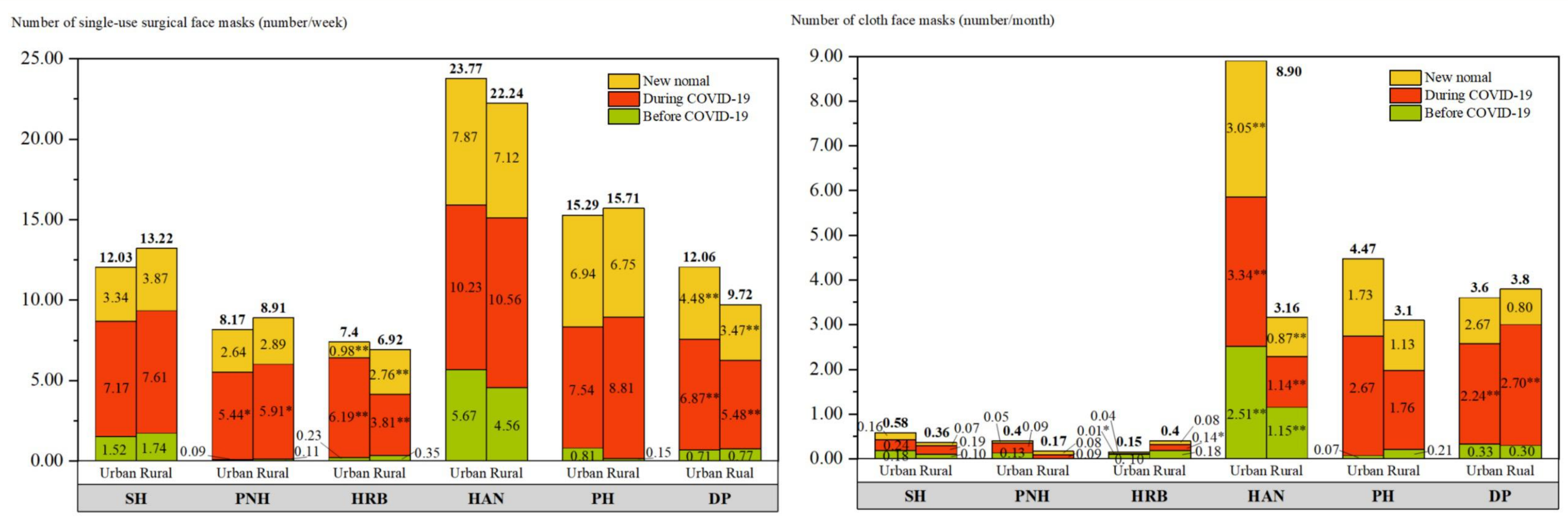


Figure 5. Urban-rural differences in mask usage.
* indicates significance at the 95% confidence.
** indicates significance at the 99% confidence.

The t-test results in Figure 5 determine the statistical significance of urban-rural differences in mask usage across different regions. Before COVID-19, there were no significant urban-rural differences in the usage of both types of face masks across the six areas. However, during COVID-19 and in the new normal, different areas exhibited varying urban-rural disparities in the usage of the two types of face masks.

Table 1. Empirical results of the significance of factors affecting mask usage.

	Single-use surgical face mask		Cloth face mask	
	Coef.	P > |t|	Coef.	P > |t|
SH				
Gender	-0.1477	0.003**	0.2055	0.447
Age	0.1071	0.001**	-0.4699	0.020*
Education level	0.0756	0.004**	0.2391	0.091
Monthly household income	0.0625	0.002**	-0.1655	0.000
PNH				
Gender	-0.0195	0.826	1.5046	0.003**
Age	-0.1418	0.000**	-0.4102	0.183
Education level	-0.0426	0.131	0.8674	0.001**
Monthly household income	-0.0220	0.463	0.1440	0.345
HRB				
Gender	-0.2279	0.002**	-0.4191	0.315
Age	-0.4951	0.000**	0.2123	0.253
Education level	0.0532	0.040*	0.4096	0.013*
Monthly household income	0.1390	0.000**	-0.3650	0.051
HAN				
Gender	-0.0465	0.300	0.3334	0.000**
Age	-0.1710	0.000**	0.0603	0.118
Education level	0.0144	0.511	-0.1193	0.003**
Monthly household income	-0.0114	0.595	0.2365	0.000**
PH				
Gender	-0.2076	0.000**	0.0644	0.553
Age	0.0088	0.660	-0.1167	0.017*
Education level	-0.0168	0.334	-0.0109	0.785
Monthly household income	-0.0191	0.410	-0.1410	0.013*
DP				
Gender	0.1959	0.004**	-0.0813	0.607
Age	-0.0564	0.044*	-0.1696	0.007**
Education level	0.0577	0.033*	-0.2779	0.000**
Monthly household income	-0.0031	0.843	-0.0760	0.026*

Poisson regression analysis, summarized in Table 1, investigated factors influencing face mask usage. In all models, chi-squared test p-values were below 0.05, signifying a highly significant statistical distinction between observed data and the independence assumption.

Table 2. The environmental impact generated by masks over a year.

	Single-use surgical face mask					Cloth face mask			
	Number (billion pieces)	Carbon footprint (million kgCO2eq)	Water footprint (million m3H2Oeq)	Solid waste (million kg)	Microplastics (trillion microplastic particles/ (piece·d))	Number (million pieces)	Carbon footprint (million kgCO2eq)	Water footprint (million m3H2Oeq)	Solid waste (million kg)
SH	4.57	146.20	105.08	15.72	1.39-3.33	35.64	13.54	70.21	0.44
PNH	0.33	10.53	7.58	1.13	0.10-0.24	1.92	0.73	3.78	0.02
HRB	1.00	31.92	22.94	3.43	0.30-0.73	7.19	2.73	14.16	0.09
HAN	3.14	100.46	72.21	10.80	0.96-2.29	191.27	72.68	376.80	2.34
MNL	5.22	166.97	120.01	17.95	1.59-3.80	251.74	95.66	495.92	3.07
DP	7.57	242.10	174.01	26.03	2.30-5.51	402.24	152.85	792.41	4.91
Toal	21.83	698.18	501.83	75.06	6.64-15.90	890	338.19	1753.28	10.87

Table 3. The changes in the environmental impact of masks.

	Carbon footprint (million kgCO2eq)	Water footprint (million m3H2Oeq)	Solid waste (million kg)	Microplastics (trillion microplastic particles/ (piece·d))
SH	-30.46	497.40	-12.00	-(1.39-3.33)
PNH	-2.20	35.88	-0.87	-(0.10-0.24)
HRB	-6.65	108.58	-2.62	-(0.30-0.73)
HAN	-20.93	341.79	-8.24	-(0.96-2.29)
MNL	-34.79	568.05	-13.70	-(1.59-3.80)
DP	-50.44	823.64	-19.87	-(2.30-5.51)
Toal	-145.47	2375.34	-57.3	-(6.64-15.90)

Table 2 displays the annual environmental impact resulting from single-use surgical and cloth face mask usage. Replacing single-use surgical face masks with cloth face masks would result in a substantial reduction in carbon footprint, solid waste, and microplastics. However, it would lead to an increase in the water footprint (Table 3).

Conclusions

This study utilized survey data to analyze the usage patterns of single-use surgical face masks and cloth face masks across six Asian areas. Individual characteristics affecting mask usage patterns were analyzed, and an estimation of the environmental impact of mask usage was conducted. Based on the research findings, relevant recommendations have been proposed, including establishing an environmentally-friendly mask supply chain, promoting sustainable mask use, and implementing awareness campaigns for proper masks selection and usage among specific demographic groups. These findings guide a balance between health and environmental concerns for more sustainable development.

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