

# BMJ Open Knowledge and behaviour of community residents' face mask-wearing during the COVID-19 pandemic: a cross-sectional study in Shanghai, China

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## ABSTRACT

**Objectives** COVID-19 is an infectious disease spreading through respiratory droplets. Using a face mask correctly is one of the essential preventive measures. We launched a survey to discover the current face mask-wearing problems for better prevention and control of the pandemic.

**Setting/participants** A cross-sectional study was conducted with 1240 residents in Shanghai during 18–28 February 2020. Stratified random sampling was adopted in the urban area, urban–rural fringe area and rural area. A mobile self-designed questionnaire was used.

**Main outcome measures** Analysis of the demographic and sociological factors influencing residents' face mask type selection, disposable surgical mask-wearing behaviour, replacement time and the storage method for reuse of disposable surgical masks.

**Results** The accuracy of residents' face mask type selection was rated 41.61% (513/1233), and that of urban–rural fringe residents, low-education residents, elderly residents, were low, respectively ( $p < 0.001$ ). 96.67% of residents always wore face masks in crowded public places. Multiple-factor analysis showed that region, gender and education level were the influencing factors for entirely fitting the disposable surgical mask to the face. Region was an influencing factor for not touching the mask's external surface while wearing or removing it. Education level was an influencing factor for recognising the external and inner mask surface, upper and lower edge of a disposable surgical mask. The accuracy of the mask replacement time was 25.63% (316/1223). It was low with elderly, low-education residents, respectively ( $p < 0.001$ ). The accuracy of residents' storage method for reuse of disposable surgical mask was 3.81% (47/1233), and region, age and education level were influencing factors.

**Conclusions** Shanghai residents recorded a high rate of wearing face masks. Selection of an appropriate type of face mask, disposable surgical mask-wearing behaviour, replacement time and storage method for reuse of disposable surgical masks should be particularly emphasised in future behaviour change interventions.

## Strengths and limitations of this study

- This is a cross-sectional survey of community residents on face mask-wearing at the early onset of COVID-19 outbreak in Shanghai, one of the first-tier cities with the most developed economy, culture and high population mobility.
- We analysed the demographic and sociological factors influencing residents' face mask type selection, disposable surgical mask-wearing behaviour, replacement time and storage method for reuse of disposable surgical masks.
- This is a large-scale community research on face mask-wearing, and our experience will provide basis for our international colleagues and authorities to prevent and control the pandemic and to combat similar public health emergencies in the future.
- Although stratified sampling was adopted, a one-to-one household investigation could not be conducted during the pandemic. We selected community residents who visited community health service centre and were willing to participate in the survey, which may increase selection bias.
- A cross-sectional study cannot examine the causal-ity or temporal relationship.

## INTRODUCTION

COVID-19 is an infectious disease caused by a newly discovered coronavirus,<sup>1,2</sup> with rapid transmission speed.<sup>3</sup> As of 18 February 2020, the pandemic had been circulating in China for more than 1 month, and the total number of confirmed cases in China had reached 74 185.<sup>4</sup> In Shanghai, China's largest port and centre of international trade and shipping,<sup>5</sup> 333 cases were confirmed,<sup>4</sup> and the pandemic continued to spread. Amid the grim situation of the COVID-19 pandemic, the Chinese Center for Disease Control and Prevention (CDC) advised the general public to wear disposable surgical masks when going to crowded public places, seeing a

doctor or taking public transportations on 28 January.<sup>6 7</sup> The Shanghai municipal government had also issued a mandatory rule, following CDC's advice, on 10 February.<sup>8</sup>

The SARS-COV-2 spreads between people in several different ways. One of the main transmission routes is through respiratory droplets. Therefore, masks play an important role in preventing COVID-19. An antihaze mask is used to block PM 2.5 particles in smog.<sup>9</sup> A cotton gauze mask is mainly used to prevent dust and keep warm in cold weather. A paper mask has no layer to block airborne particles. None of the three kinds of masks has the effect of blocking the virus. Disposable surgical masks with a three-layer structure are ubiquitous. The outer layer is a waterproof layer used to prevent liquid spatter, the middle layer is a filter layer designed for blocking virus and bacteria and the inner layer is a moisture-resistant layer designed for absorbing moisture. Compared with disposable surgical masks, N95 respirators are optimised in structure with core filtration and filtering efficiency up to 95%.<sup>10</sup> There are many promising studies worldwide showing that wearing face masks could reduce the spread of SARS-COV-2<sup>11-13</sup> and the improper use of face masks may increase the risk of infection.<sup>14 15</sup> For the correct use of disposable surgical masks, the way of mask wearing is crucial, and the mask replacement time also needs to be paid attention. Disposable surgical masks should be discarded after 4 hours of use,<sup>7 16</sup> because their bacterial filtration efficacy decreases significantly after 4 hours.<sup>17</sup> In early February 2020, an online survey of 22 302 residents in Guangdong Province showed that only 35.3% of residents replaced their masks every 4 hours.<sup>18</sup> Scalvenzi *et al.*<sup>19</sup> found that only 34.2% of residents replaced masks within 3–4 hours of continuous use. The correct rate of mask replacement behaviour was low both at home and abroad.

At that time, antipandemic personnel protective supplies were scarce, and the government stepped up the production of disposable surgical masks.<sup>20</sup> Disposable surgical masks used to be worn by medical staff had now become the most commonly used antipandemic personnel protective supply for Shanghai residents. In our daily work and daily life, we found that many community residents had many problems with the use of disposable surgical masks. However, will the improper use of disposable surgical masks occur in residents of all the communities in Shanghai? It is necessary to conduct a survey on the knowledge and behaviour of community residents' wearing face masks in Shanghai to find potential problems and provide an effective prevention strategy on face mask-wearing behaviour to confront the emerging infectious disease.

## MATERIALS AND METHODS

### Participants

The cross-sectional survey was conducted between 18 and 28 February 2020. Stratified random sampling was adopted. According to the regional division of Shanghai,

regions were divided into the urban, urban–rural fringe and rural areas.<sup>21</sup> One district was randomly selected from each of the three areas, and one community health service centre (CHC) was randomly selected from each district. Then, Xujiahui CHC in Xuhui District, Jinyang CHC in Pudong New Area and Xinhe CHC in Chongming District were selected as investigation sites.

According to the formula

$$n = \frac{\mu_{\alpha/2}^2 \pi(1-\pi)}{\delta^2}$$

$N$  stands for the required sample size.  $\mu_{\alpha/2}$  stands for the  $\mu$  value when the cumulative probability from left to right is  $1-\alpha/2$  (both sides) in the standard normal distribution.  $\pi$  stands for the accuracy rate of all the questions in the presurvey.  $\delta$  stands for the allowable error.

Based on the presurvey results of 70 respondents,  $\pi=0.0143$ ,  $1-\pi=0.987$ ,  $\alpha=0.05$  was set,  $\mu_{\alpha/2}=1.96$ , a 5% margin of error was set, then  $\delta=0.5$ ,  $\pi=0.00715$ , the total number of respondents is:

$$n = \frac{1.96^2 \times 0.0143 \times 0.9857}{0.00715^2} = 1059.2 \approx 1060$$

The sample size of each community was determined according to the proportion of the number of permanent residents in each community covered by each CHC.<sup>22</sup> So we should invite at least 310 respondents from Xujiahui, 614 from Jinyang and 136 from Xinhe. No incentive was offered for completion of the questionnaire.

The inclusion criteria were: CHC outpatients aged 18 or over and volunteered to cooperate for the investigation.

The exclusion criteria were: CHC outpatients aged below 18, or had cognitive impairment and severe hearing impairment and could not cooperate or refused to complete the investigation.

Finally, 1293 respondents were invited, 53 refused to complete the investigation, 1240 questionnaires were collected, with a response rate of 95.90%; 7 questionnaires with incorrect age filling were excluded. In total, 1233 valid questionnaires were collected; 361 residents in Xujiahui, 714 in Jinyang and 158 in Xinhe were included. The effective recovery rate was 99.44% (1233/1240).

### Procedure

The investigation team of each CHC included five general practitioners (GPs). All of them had received unified online training before the investigation. Those who could use mobile phone completed the online questionnaires on Wechat. Those who could not use mobile phone completed the questionnaires on paper, the data of which were later input into the Wechat platform by related GPs. Regardless of the online or paper questionnaires, the process of questionnaire completion was supervised by GPs on the spot to ensure that the quality of the questionnaire reply meet the research requirements. All entries were required, and if there were omissions, they could not be submitted.

### Measures

A mobile self-designed questionnaire was used. The content includes the general information of the

respondents and eight questions; 1 multiple-choice question of face mask type selection during the COVID-19 pandemic, 1 single-choice question of face mask-wearing, 4 questions (three single-choice, one multiple-choice) on how to wear the masks, 1 single-choice question of the mask replacement time and one multiple-choice question of storage method for reuse of disposable surgical masks. For all multiple-choice questions, respondents must check all the correct items to be judged as correct. Cronbach's alpha value of the questionnaire is 0.816, and the data have high internal consistency and strong reliability.

### Data analysis

Excel (Microsoft Office Professional Plus 2010) was used to establish the database, and SPSS (V.20) was used for data processing and analysis. Measurement data were expressed as mean (X)±SD (S) and count as percentage(%).  $\chi^2$  test was used for single-factor analysis, and  $p < 0.05$  indicated that the difference was statistically significant. Logistic regression was used for multiple-factor analysis. The behaviour of wearing disposable surgical masks correctly or not was taken as the outcome variable, and the factors which had statistical significance in the single-factor analysis, such as region, gender and age, were taken as the predictors. The parameters were estimated by the enter method. OR values and their CIs were used to analyse the relative risk of variables.

### Patient and public involvement

The public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

## RESULTS

### Demographic and sociological characteristics of the respondents

Among the 1233 respondents, the average age was 67.03 years old, ranging from 18 to 92. There were 543 males and 690 females. The majority did not live alone. Compared with other communities, Xujiahui had more residents aged over 80, and Xinhe had more residents with elementary education and below, and the difference was statistically significant ( $p < 0.05$ ) (table 1).

### Face mask type selection

24.01% of the residents selected only disposable surgical masks to prevent COVID-19 (296/1233). 3.65% selected only N95 masks to prevent COVID-19 (45/1233). 513 residents (41.61%) correctly selected both disposable surgical masks and N95 masks to prevent COVID-19. The correct rate of face mask type selection varied with different region, age and education level. Urban-rural fringe residents, residents aged 70 and above and residents with elementary education and below had low correct rate of face mask type selection (table 2).

**Table 1** General information of respondents (N (%))

Characteristics	Xujiahui	Jinyang	Xinhe	Total	$\chi^2$	P value
<b>Gender</b>						
Male	171 (47.37)	304 (42.58)	68 (43.04)	543 (44.04)	2.307	0.315
Female	190 (52.63)	410 (57.42)	90 (56.96)	690 (55.96)		
<b>Age</b>						
<60	60 (16.62)	162 (22.69)	25 (15.82)	247 (20.03)	13.412	0.037
≥60 and <70	139 (38.50)	262 (36.70)	63 (39.87)	464 (37.63)		
≥70 and <80	109 (30.20)	224 (31.37)	49 (31.01)	382 (30.98)		
≥80	53 (14.68)	66 (9.24)	21 (13.30)	140 (11.36)		
<b>Education</b>						
Elementary education and below	33 (9.14)	118 (16.53)	70 (44.30)	221 (17.92)	151.008	<0.001
Junior high school	217 (60.11)	424 (59.38)	77 (48.73)	718 (58.23)		
Senior high school and technical school	95 (26.32)	87 (12.19)	11 (6.96)	193 (15.65)		
College and above	16 (4.43)	85 (11.90)	0 (0.00)	101 (8.20)		
<b>Marriage</b>						
Unmarried	2 (0.55)	17 (2.39)	1 (0.63)	20 (1.62)	6.902	0.141
Married	324 (89.75)	617 (86.41)	139 (87.97)	1080 (87.60)		
Divorced or widowed	35 (9.70)	80 (11.20)	18 (11.39)	133 (10.79)		
<b>Living status</b>						
Living alone	15 (4.16)	62 (8.68)	13 (8.23)	90 (7.30)	7.497	0.024
Non-living alone	346 (95.84)	652 (91.32)	145 (91.77)	1143 (92.70)		

**Table 2** Comparison of correct face mask type selection by respondents (N(%))

Characteristics	Face mask type selection	$\chi^2$	P value
<b>Region</b>			
Xujiahui	199 (55.12)	38.398	<0.001
Jinyang	257 (35.00)		
Xinhe	57 (36.08)		
<b>Gender</b>			
Male	237 (43.65)	1.663	0.197
Female	276 (40.00)		
<b>Age</b>			
<60	142 (57.49)	37.156	<0.001
≥60 and <70	192 (41.38)		
≥70 and <80	131 (34.29)		
≥80	48 (34.29)		
<b>Education</b>			
Elementary education and below	58 (26.24)	57.956	<0.001
Junior high school	285 (39.69)		
Senior high school and technical school	104 (53.89)		
College and above	66 (65.35)		

### Proportion of people wearing face masks

96.67% (1192/1233) of the respondents replied that they always wore face masks in crowded public places. The proportion of the respondents who often wore face masks, sometimes wore face masks, and never wore face masks was 2.51% (31/1233), 0.65% (8/1233) and 0.17% (2/1233), respectively.

### Disposable surgical mask-wearing behaviour

#### The correct rate of disposable surgical mask-wearing

The correct rate of residents' distinguishing the external and inner disposable surgical mask surface was 84.83%. The correct rate of residents' distinguishing the upper and lower mask edge was 84.02%. The correct rate of fitting the mask entirely to the face was 28.63%. The correct rate of not touching the mask's external surface while wearing or removing it was 22.87%.

#### Single-factor analysis of disposable surgical mask-wearing behaviour

The correct rate of urban residents' distinguishing the upper and lower mask edge, fitting the mask entirely to the face and not touching the mask's external surface while wearing or removing it was the lowest ( $p<0.001$ ). The correct rate of male residents' distinguishing the upper and lower mask edge, fitting the mask entirely to the

face and not touching the mask's external surface while wearing or removing it was the lowest ( $p=0.011$ ,  $p=0.022$ ,  $p=0.027$ ). The correct rate of residents aged 80 and above for distinguishing the external and inner surface, upper and lower mask edge and fitting the mask entirely to the face was the lowest ( $p<0.001$ ). Residents with elementary education and below had the lowest correct rate in distinguishing the external and inner mask surface and fitting the mask entirely to the face ( $p<0.001$ ) (table 3).

#### Multifactor analysis of disposable surgical mask-wearing behaviour

Region was an influencing factor for respondents fitting the disposable surgical mask entirely to the face and not touching the mask's external surface while wearing or removing it. The correct rate of urban residents was the lowest. Gender was an influencing factor for fitting the mask entirely to the face. The correct rate of male was lower than that of female. Education level was an influencing factor for distinguishing the external and inner surface, upper and lower mask edge and fitting the mask entirely to the face. The correct rate of residents with college education and above was the highest (table 4).

#### Replacement time of disposable surgical mask

39.01% (481/1233) of the residents discarded the disposable surgical mask at the interval of 2–3 days, and 27.33% (361/1233) of them discarded the mask every day. 25.63% (316/1223) of the residents discarded the mask every 4 hours, judged as correct behaviour. The mask replacement time of residents differed with age and education level ( $p<0.001$ ). The older the age, or the lower the education level, the lower the correct rate (table 5).

#### Storage method for reuse of disposable surgical mask

36.58% (451/1233) of residents did not master even one correct way of storing disposable surgical masks for reuse, 50.28% (620/1233) mastered only one correct way, 9.33% (115/1233) mastered two correct ways. Only 3.81% (47/1233) mastered three correct ways, judged as correct behaviour. The correct rate of urban–rural fringe residents, residents aged between 70 and 80 and residents with education level of junior high school were the lowest ( $p<0.001$ ) (table 5).

## DISCUSSION

The significant findings of our study were that nearly everyone wore face masks in crowded public places during the COVID-19 outbreak. However, the appropriate selection of face mask types needs to be improved. In disposable surgical mask-wearing behaviour, how to fit the mask entirely to the face, not touching the mask's external surface while wearing or removing it, replacement time and storage method for reuse of disposable surgical masks should be particularly emphasised. Furthermore, our study suggested that different regions, gender and

**Table 3**  $\chi^2$  test of correct disposable surgical mask-wearing behaviour by respondents (N(%))

Characteristics	Distinguish external and inner surface	Distinguish upper and lower edge	Fit the mask entirely to the face	Hands not touching the external surface
<b>Region</b>				
Xujiahui	323 (89.47)	235 (65.10)	42 (11.63)	27 (7.48)
Jinyang	589 (82.49)	654 (91.60)	275 (38.52)	179 (25.07)
Xinhe	134 (84.81)	147 (93.04)	36 (22.78)	76 (48.10)
$\chi^2$	9.081	136.395	87.822	107.455
P value	0.011	<0.001	<0.001	<0.001
<b>Gender</b>				
Male	464 (85.45)	440 (81.03)	142 (26.15)	108 (19.89)
Female	582 (84.35)	596 (86.38)	211 (30.58)	174 (25.22)
$\chi^2$	0.288	6.468	5.225	4.890
P value	0.592	0.011	0.022	0.027
<b>Age</b>				
<60	209 (84.62)	219 (88.66)	109 (44.13)	59 (23.89)
≥60 and <70	408 (87.93)	409 (88.15)	118 (25.43)	111 (23.92)
≥70 and <80	328 (85.86)	312 (81.68)	97 (25.39)	80 (20.94)
≥80	101 (72.14)	96 (68.57)	29 (20.71)	32 (22.86)
$\chi^2$	21.309	36.307	36.617	1.241
P value	<0.001	<0.001	<0.001	0.743
<b>Education</b>				
Elementary education and below	165 (74.66)	180 (81.45)	41 (18.55)	74 (33.48)
Junior high school	623 (86.77)	607 (84.54)	211 (29.39)	152 (21.17)
Senior high school and technical school	165 (85.49)	155 (80.31)	50 (25.91)	33 (17.10)
College and above	93 (92.08)	94 (93.07)	51 (50.50)	23 (22.77)
$\chi^2$	24.052	9.373	35.519	18.936
P value	<0.001	0.025	<0.001	<0.001

education levels affected different aspects of disposable surgical mask-wearing behaviour.

CDC recommends using disposable surgical masks and N95 masks in preventing novel coronavirus.<sup>7</sup> Our survey showed that only 41.61% (513/1233) of residents could properly select both of disposable surgical mask and N95 mask to prevent novel coronavirus. Qi *et al*<sup>23</sup> investigated face mask type selection by 3083 residents in China to prevent COVID-19 on 29 January 2020 and found that 65.46% selected both disposable surgical mask and N95 mask. Their correct rate was higher than ours. Our study showed that the correct rate of urban–rural fringe residents (35.00%) and rural residents (36.08%) were lower than that of urban residents (55.12%). Qi *et al*<sup>23</sup> demonstrated that the knowledge level of urban residents was higher than rural residents, which may be related to the fact that urban residents had higher education level than rural residents, and they received more health information in daily life.<sup>24</sup> This suggests that in carrying out COVID-19 health education, we should strengthen the publicity work in urban–rural fringe areas and rural areas and use targeted publicity methods according to the characteristics of the population in different regions. In

our study, the correct rate of elderly and low-educated residents was low. Zhu *et al*<sup>25</sup> conducted a survey of 872 rural residents in Fujian on face mask type selection in February 2020. It showed the same trend that the higher the age, or the lower the education level, the lower the correct rate. Hence, we should focus on popularising the functional knowledge of face masks among residents in urban–rural fringe areas and elderly residents. For those with a low education level, we should provide them with booklets or videos to easily understand and choose the correct types of face masks. Some residents mistakenly chose antihaze masks and cotton gauze masks, possibly due to their living habits in certain regions of Shanghai. Although our study suggested that most of the residents in Shanghai wore face masks in crowded public places, if they wore the wrong type of mask, the goal of preventing the spread of virus could not be achieved. Therefore, it is necessary to raise the awareness of the function of different types of face masks among residents.

According to our investigation, the proportion of residents who always wore face masks in crowded public places reached 96.67%. This is consistent with the results of a Hong Kong study<sup>26</sup> of 10211 residents in February

**Table 4** Multifactor analysis of correct disposable surgical mask-wearing behaviour by respondents (OR(95% CI))

	Distinguish external and inner surface	Distinguish upper and lower edge	Fit the mask entirely to the face	Hands not touching the external surface
<b>Region</b>				
Xujiahui	1	1	1	1
Jinyang	0.519 (0.347 to 0.778)	0.520 (0.347 to 0.778)	5.887 (4.099 to 8.455)	4.007 (2.599 to 6.177)
Xinhe	0.811 (0.452 to 1.455)	0.810 (0.451 to 1.455)	9.041 (4.519 to 18.087)	10.579 (6.297 to 17.775)
<b>Gender</b>				
Male	—	1	1	1
Female	—	0.980 (0.705 to 1.362)	1.412 (1.004 to 1.987)	1.318 (0.99 to 1.754)
<b>Age</b>				
<60	1	1	1	—
≥60 and <70	1.516 (0.951 to 2.418)	1.512 (0.946 to 2.416)	1.259 (0.738 to 2.146)	—
≥70 and <80	1.369 (0.846 to 2.214)	1.363 (0.838 to 2.217)	0.725 (0.427 to 1.233)	—
≥80	0.638 (0.361 to 1.13)	0.634 (0.356 to 1.132)	0.448 (0.236 to 0.85)	—
<b>Education</b>				
Elementary education and below	1	1	1	1
Junior high school	1.908 (1.256 to 2.901)	1.903 (1.248 to 2.9)	1.542 (0.948 to 2.506)	0.774 (0.541 to 1.107)
Senior high school and technical school	1.621 (0.918 to 2.86)	1.612 (0.908 to 2.863)	1.560 (0.836 to 2.91)	0.796 (0.48 to 1.321)
College and above	4.353 (1.876 to 10.102)	4.324 (1.85 to 10.106)	3.064 (1.18 to 7.956)	0.875 (0.491 to 1.557)

2020 and Sun *et al*'s online survey<sup>27</sup> of 5761 residents in China in March 2020. The proportion of Shanghai residents' wearing masks during the pandemic was high, and this might be closely associated with the continuous improvement of health literacy of Shanghai citizens in recent years, the mandatory measures that the Shanghai government had imposed on citizens to wear masks when accessing crowded public places,<sup>28</sup> the multichannel popular science publicity tools such as radio, newspapers, citizen hotlines, websites of hospitals at all levels, social media public accounts, telephone consultation platforms and community neighbourhood committees under the grim situation. In February 2020, Chen *et al*<sup>29</sup> investigated face mask-wearing behaviour of 8569 elementary school students in Wuhan, and found that only 51.60% of them wore face masks. Children are the future of the country and the treasure of their parents. However, even in the worst-hit areas, the status quo of primary school students' face mask-wearing behaviour was not optimistic. This finding may also be related to the lack of personnel protective supplies during the pandemic.

We further investigated disposable surgical mask-wearing behaviour. Based on the function principle of the three-layer structure of disposable surgical masks, if the inside or external surface of the mask is worn inside-out, it will inevitably lose its effect in preventing respiratory infectious diseases. Our study showed that 84.83% of Shanghai residents could correctly distinguish the

disposable surgical masks' inside and external surface. If the disposable surgical mask is worn upside-down or the metal strip is not pressed, it will leave a gap between the mask and the face, so droplets cannot be prevented. We found that 84.02% of the respondents could correctly distinguish the disposable surgical mask's upper and lower edges. The Hong Kong study found that up to 35.5% of residents wore masks inside-out or upside-down,<sup>26</sup> similar to our findings. When one wears a disposable surgical mask, the metal strip embedded in the upper part of the mask must be pressed against the bridge of the nose so that the mask and the face can entirely fit together to prevent droplets.<sup>30</sup> In our study, the correct rate of this behaviour among Shanghai community residents was only 28.25%. In February 2020, a study of 200 residents in Zhongshan city, Guangdong province, showed that the incorrect rate of wearing a medical mask was 52.5%, among which not fitting the medical mask entirely to the face was the leading incorrect way.<sup>31</sup> There was difference in the correct rate of wearing medical masks between residents in Shanghai and Zhongshan, which may be related to small sample size and lack of representativeness in the sample of Zhongshan City. There is no report on the correct rate of wearing medical masks abroad. To press the metal strip against the bridge of the nose so that the mask and the face can fully fit together should be particularly emphasised in future behaviour change intervention. While the disposable surgical mask

**Table 5** Correct replacement time and storage method for reuse of disposable surgical masks by respondents (N(%))

Characteristics	Replacement time	$\chi^2$	P value	Storage method for reuse	$\chi^2$	P value
<b>Region</b>						
Xujiahui	99 (27.42)	8.654	0.070	31 (8.59)	33.775	<0.001
Jinyang	188 (26.33)			10 (1.40)		
Xinhe	29 (18.35)			6 (3.80)		
<b>Gender</b>						
Male	130 (23.94)	3.099	0.212	20 (3.68)	0.044	0.834
Female	186 (26.96)			27 (3.91)		
<b>Age</b>						
<60	93 (37.65)	29.984	<0.001	12 (4.86)	12.164	<0.001
≥60 and <70	114 (24.57)			13 (2.80)		
≥70 and <80	83 (21.73)			10 (2.62)		
≥80	26 (18.57)			12 (8.57)		
<b>Education</b>						
Elementary education and below	42 (19.00)	22.611	<0.001	22 (9.95)	35.620	<0.001
Junior high school	170 (23.68)			11 (1.53)		
Senior high school and technical school	68 (35.23)			7 (3.63)		
College and above	36 (35.64)			7 (6.93)		

Correct mask replacement time interval:4 hours.

Correct storage method for reuse of disposable surgical mask.

Place a layer of clean paper towel on the table, then place the mask flat on top of the paper towel (external surface down) and then cover the mask with another layer of clean paper.

Fold the mask in half (with the external surface of the mask facing outward), put the mask into an envelope or a bag and avoid touching the inner surface of the mask by hand.

Hang the mask in a clean, dry and ventilated place.

is worn or taken off, if one's hands touch its external surface, which is used to block virus and particles, it will increase the risk of infection.<sup>32</sup> Our research showed that the behaviour of not fitting the disposable surgical mask entirely to the face, hand touching the external mask surface while wearing or removing it were both weak links in mask-wearing among Shanghai community residents. Only 22.87% of the respondents' hands did not touch the external mask surface while wearing or removing it. Tan *et al*<sup>33</sup> found that 55.3% touched their mask and 62.1% adjusted their mask while wearing it. It reminds us of the necessity to strengthen publicity and guidance to promote public awareness of the importance of hand hygiene when wearing or removing the masks to better prevent infectious diseases.

Multivariate analysis showed that region was an influencing factor for fitting the disposable surgical mask entirely to the face and hand not touching its external surface while wearing or removing it. The correct rate of urban residents was the lowest. The central urban area has a higher standard of medical care, and there are more channels for obtaining prevention and control information for residents in the urban area. However, the proportion of urban residents understanding how to wear a disposable surgical mask correctly was the lowest,

and this is worth pondering. On the one hand, it may be related to the number of respondents aged 80 and above enrolled in our study being the highest in urban areas.<sup>34</sup> On the other hand, it suggests that in urban areas, attention should be paid to strengthening the management of information through the internet and other channels to avoid misleading residents with false and erroneous information. The central urban area is densely populated and more susceptible to infection. This alerts us that we should popularise mask-wearing procedures in detail and ensure the work is well implemented. We had also observed that gender was an influencing factor for fitting the disposable surgical mask entirely to the face, and the correct rate of males was lower than that of females. A small-sample study of 200 people in Zhongshan City in 2020 also showed that women had a better understanding of properly wearing masks than men.<sup>31</sup> At present, there is a lack of extensive sample studies on mask-wearing at home and abroad. Women are at the core of family life and are more careful in obtaining knowledge of pandemic protection, which is conducive to improving the health of the whole family.<sup>35</sup> Research such as Qi *et al*<sup>23</sup> showed that women were more knowledgeable than men about COVID-19 pandemic prevention. Therefore, in popular science campaigns, health education should

be focused on male, and female at the core of family life can also be mobilised to educate male family members. Education level was another influencing factor for distinguishing the upper and lower edge, the external and inner mask surface, fitting the mask entirely to the face, and the correct rate of mask-wearing behaviour of those with college education and above was the highest. Our study suggested that for people with low education levels, easy-to-understand promotional materials suitable for their characteristics, such as cartoons, animations, radios, videos, should be selected to correct people's improper face mask-wearing behaviour.

In our study, 25.63% of the residents replaced disposable surgical masks every 4 hours. The older the age, or the lower the education level, the lower the correct rate. Community residents must master the correct mask replacement time to deal with various respiratory infectious diseases at present and in the future. During the shortage of antipandemic protective personnel supplies, it was inevitable that disposable surgical masks were used many times. There are three correct ways to store disposable surgical masks for reuse.<sup>36</sup> First is to place a layer of clean paper towel on the table, then place the mask flat on top of the paper towel (with external surface down), at last, cover the mask with another layer of clean paper. The second is to fold the mask in half (with the external surface facing outward), put the mask into an envelope or a bag and avoid touching the inner mask surface by hand. The third is to hang the mask in a clean, dry and ventilated place. In our study, 50.28% of the residents knew one correct storage way, 9.33% knew two correct storage ways and only 3.8% knew three correct storage ways. 36.8% of the residents failed to master even one correct storage way. Some residents were unclear and just stored the disposable surgical mask randomly. Other residents folded the mask in half with the external surface of the mask facing outward, and put it in the pocket or hung it around the arm. This wrong mask storage way is counterproductive to preventing the spread of infection and will lead to an increased risk of contamination. Some residents sprayed the mask with alcohol or wiped it with alcohol cotton and then stored it in a clean paper bag. Alcohol disinfection will lead to a decrease in the filtration efficiency of the mask.<sup>37</sup> 65.6% of respondents in Tan *et al*'s study correctly chose to hang their masks in well-ventilated places.<sup>33</sup> Scalvenzi *et al*<sup>19</sup> showed that only 34.4% declared to keep their mask in a specific plastic bag when they were not wearing it. On the one hand, with the shortage of antipandemic protective personnel supplies, it is necessary for our medical staff to instruct residents on the correct storage method for reuse of disposable surgical masks. On the other hand, medical staff can thoroughly learn from the Italian dermatology clinic, use telemedicine to reduce residents' visits to clinics, avoid face-to-face treatment, and reduce the risk of infection.<sup>38–40</sup>

## Limitations

The survey has some limitations. Although we randomly selected urban, urban–rural fringe, rural area of Shanghai, a one-to-one household investigation could not be conducted during the pandemic. We selected community residents who visited CHC and were willing to participate in the survey, which increased the possibility of selection bias. The study did provide necessary reference for the gap in knowledge and practice, but the extrapolation of conclusions was limited to some extent. Because the study was based on a cross-sectional design, a causal relationship could not be inferred with certainty. And people might feel uncomfortable with forced choices in the survey. Self-reported data were another limitation. As the study was done in February 2020, the very beginning of the pandemic, the findings may not represent what Shanghai people behave later during the pandemic. It may be a good future research idea to replicate this study and see whether people have become less willing to adhere those face mask use policies.

## CONCLUSIONS

This is a large-scale cross-sectional survey on face mask-wearing of community residents in Shanghai during the pandemic of COVID-19. Our findings suggested that most Shanghai residents used face masks in crowded public places. However, the appropriate selection of face mask types needs to be improved. In disposable surgical mask-wearing behaviour, how to fit the mask entirely to the face, hands not touching the mask's external surface while wearing it or removing it, the replacement time and storage method for reuse of disposable surgical masks should be particularly emphasised in future behaviour change interventions. We need to enhance targeted health promotion activities for different groups to promote residents' correct mask-wearing behaviours and build the first defensive line of community prevention and control.

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## REFERENCES

- Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med* 2020;382:1199–207.
- World Health Organization. Naming the coronavirus disease (COVID-19) and the virus that causes it, 2020. Available: [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-\(covid-2019\)-and-the-virus-that-causes-it](https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it)
- World Health Organization. Novel-coronavirus-2019 strategies-plans-and-operations. Available: [https://www.who.int/docs/default-source/coronaviruse/strategy-update-chinesefinal.pdf?sfvrsn=29da3ba0\\_19](https://www.who.int/docs/default-source/coronaviruse/strategy-update-chinesefinal.pdf?sfvrsn=29da3ba0_19)
- Shanghai Municipal Health Commission. No new confirmed cases of novel coronavirus pneumonia in Shanghai. *wsjkw.sh.gov.cn*, 2020. Available: <http://wsjkw.sh.gov.cn/xwfb/20200219/645a012cb78a4c109ace96293ecd0e2e.html>
- State Council of China. Approval of the state Council on the Shanghai City master plan, 2020. Available: [http://www.gov.cn/zhengce/content/2017-12/25/content\\_5250134.htm](http://www.gov.cn/zhengce/content/2017-12/25/content_5250134.htm)
- Bureau of disease control. National health Commission, notice on issuing guidelines for the prevention of new coronavirus infection among people at different risk levels and for the use of respirators to prevent new coronavirus infection. Available: [www.gov.cn.2020. http://www.gov.cn/2020-01/31/content\\_5473401.htm](http://www.gov.cn/2020-01/31/content_5473401.htm)
- Bureau of disease control and Prevention. *Guidelines for public protection of pneumonia caused by new coronavirus*. People's Health Publishing House, 2020.
- Shanghai Municipal Government. Notice on the further strict implementation of the epidemic prevention and control measures. *mp.weixin.qq.com*, 2020. Available: [https://mp.weixin.qq.com/s/1Mv-XGG\\_g0wM3c8tJM5sQq](https://mp.weixin.qq.com/s/1Mv-XGG_g0wM3c8tJM5sQq)
- Matuschek C, Moll F, Fangerau H, et al. The history and value of face masks. *Eur J Med Res* 2020;25:23.
- Lin Q, Huang Y, Sun G. Feasibility of reuse and disinfection of single-use medical masks in a novel coronavirus pneumonia pandemic. *Journal of Nursing Management* 2020;20:280–4.
- Mitze T, Kosfeld R, Rode J, et al. Face masks considerably reduce COVID-19 cases in Germany. *Proc Natl Acad Sci U S A* 2020;117:32293–301.
- Leung NHL, Chu DKW, Shiu EYC, et al. Author correction: respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med* 2020;26:981–1.
- Eikenberry SE, Mancuso M, Iboi E, et al. To mask or not to mask: modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infect Dis Model* 2020;5:293–308.
- Kumar J, Katto MS, Siddiqui AA, et al. Knowledge, attitude, and practices of healthcare workers regarding the use of face mask to limit the spread of the new coronavirus disease (COVID-19). *Cureus* 2020;12:e7737.
- Feng S, Shen C, Xia N, et al. Rational use of face masks in the COVID-19 pandemic. *Lancet Respir Med* 2020;8:434–6.
- Miao H. Personal protection against novel coronaviruses. *Microbiology and Infection* 2020;15:41–3.
- Barbosa MH, Graziano KU. Influence of wearing time on efficacy of disposable surgical masks as microbial barrier. *Brazilian Journal of Microbiology* 2006;37:216–7.
- Cai H, Zhu Y, Lei L. Novel coronavirus pneumonia-related knowledge, behavior and psychological responses: a web-based cross-sectional survey. *Public Health China* 2020;36:152–5.
- Scalvenzi M, Villani A, Ruggiero A. Community knowledge about the use, reuse, disinfection and disposal of masks and filtering Facepiece respirators: results of a study conducted in a dermatology clinic at the University of Naples in Italy. *J Community Health* 2021;46:786–93.
- Xinmin Evening News. Shanghai carried out emergency review and approval on medical surgical masks and disposable medical protective clothing urgently needed for epidemic prevention and control. *baijiahao.baidu.com*, 2020. Available: <https://baijiahao.baidu.com/s?id=1657587909898827869&wfr=spider&for=pc>
- Xu J, Peng Y, Shi Y. Study on hospice service delivery and compensation in Shanghai community health service center. *China's health economy* 2020;38:64–7.
- National Bureau of Statistics of China (NBS). Summary data from the sixth national census. Available: [www.stats.gov.cn.2020. http://www.stats.gov.cn/tjsj/pcsj/rkpc/d6c/t20120718\\_402819792.html](http://www.stats.gov.cn/tjsj/pcsj/rkpc/d6c/t20120718_402819792.html)
- Qi Y, Chen Y, Zhang L. Public practice, attitude and knowledge of coronavirus disease. *Journal of Tropical Medicine* 2020;20:145–9.
- Li N. *Research on the health literacy status and influencing factors of urban and rural residents in Hebei Province*. Jilin University, 2016.
- Zhu L, Fu L, Zhou X. Analysis of the current situation of knowledge, skills and care needs of rural residents in Fujian Province for the prevention of novel coronavirus pneumonia. *Nursing Research* 2020;34:1649–53.
- Tam VC, Tam SY, Poon WK, et al. A reality check on the use of face masks during the COVID-19 outbreak in Hong Kong. *EClinicalMedicine* 2020;22:100356.
- Sun CX, He B, Mu D, et al. Public awareness and mask usage during the COVID-19 epidemic: a survey by China CDC new media. *Biomed Environ Sci* 2020;33:639–45.
- Zhang W. Zhang Wenhong's novel coronavirus pneumonia(1): we come from the dark hour. *mp.weixin.qq.com*, 2020. Available: <https://mp.weixin.qq.com/s/-2r05aZKcneexG-65iz0CA>
- Chen X, Ran L, Liu Q, et al. Hand hygiene, Mask-Wearing behaviors and its associated factors during the COVID-19 epidemic: a cross-sectional study among primary school students in Wuhan, China. *Int J Environ Res Public Health* 2020;17:2893.
- World Health Organization. Advice on the use of masks the community, during home care and in health care settings in the context of the novel coronavirus (2019-nCoV) outbreak. *www.who.int*, 2020. Available: [www.who.int/docs/default-source/documents/advice-on-the-use-of-masks-2019-ncov.pdf](https://www.who.int/docs/default-source/documents/advice-on-the-use-of-masks-2019-ncov.pdf)
- Lv Q, Dong R, Xie G. On strengthening the management of disposable mask use. *Health Must Read* 2020;4:258.
- Ran L, Chen X, Wang Y, et al. Risk factors of healthcare workers with coronavirus disease 2019: a retrospective cohort study in a designated hospital of Wuhan in China. *Clin Infect Dis* 2020;71:2218–21.
- Tan M, Wang Y, Luo L, et al. How the public used face masks in China during the coronavirus disease pandemic: a survey study. *Int J Nurs Stud* 2021;115:103853.
- Zhang J, Zou L, Jiao C, et al. Cognitive benefits of activity engagement among 12,093 adults aged over 65 years. *Brain Sci* 2020;10:967.
- Lu D. The important role of mothers in family education. *Parenting* 2020;49:51.
- Wang P, Ye D, Zheng Z. The role of masks in the prevention of novel coronavirus infections and their selection and use. *Guangdong Medicine* 2020;41:865–8.
- Grinshpun SA, Yermakov M, Khodoun M. Autoclave sterilization and ethanol treatment of re-used surgical masks and N95 respirators during COVID-19: impact on their performance and integrity. *J Hosp Infect* 2020;105:608–14.
- Marasca C, Ruggiero A, Annunziata MC, et al. Face the COVID-19 emergency: measures applied in an Italian dermatologic clinic. *J Eur Acad Dermatol Venereol* 2020;34:e249.
- Villani A, Megna M, Scalvenzi M, et al. Teledermatology and chronic skin diseases: real life experience in a southern Italian dermatologic centre. *Dermatol Ther* 2020;33:e13839.
- Ruggiero A, Megna M, Annunziata MC, et al. Teledermatology for acne during COVID-19: high patients' satisfaction in spite of the emergency. *J Eur Acad Dermatol Venereol* 2020;34:e662–3.