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Short Communication

Masks for Influenza Patients: Measurement of Airflow from the Mouth

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SUMMARY: In case of a new influenza pandemic, provision of masks to coughing patients could be used to slow expansion of the epidemic. To quantitatively assess the efficacy of different masks, we used an ultrasonic anemometer to measure the velocity of airflow from the mouth in coughing. We found that even the cheapest paper masks reduced the airspeed to less than 1/10, implicating their effectiveness in decreasing viral spread. We therefore propose that governments provide free masks to coughing patients in the general population upon the emergence of a new human influenza virus.

Many countries are now preparing against a new influenza pandemic that may occur sometime in the future. Antiviral drugs and vaccine are considered to be a primary deterrent. As a nonpharmaceutical intervention (1), the use of face masks is also being considered; it is thought that (i) the wearing of masks by coughing patients can decrease spread of the virus to susceptible people, and (ii) wearing by healthy individuals can help them avoid infection. However, the efficacy of masks against influenza has not been quantitatively studied.

From a public-health perspective, blocking viral spread with masks at a point of origin, that is, coughing patients, is more efficient than blocking virus particles that have been scattered in the air with masks worn by susceptible persons. Furthermore, virus particles in wet droplets just after expulsion from a patient's mouth are more easily trapped by masks than the particles in the dry, smaller-sized droplet nuclei that are airborne to healthy persons. However, it is not easy to evaluate the ability of masks to block the virus itself.

In the present study, by using an ultrasonic anemometer, we measured the velocity of the airflow from the mouth in coughing and then compared three kinds of masks of various prices with regard to their ability to reduce the airspeed. We found that the cheapest paper masks as well as other masks substantially reduced the speed, implicating that masks greatly decrease virus spread from patients.

The sensor of an ultrasonic anemometer/thermometer (DA-600; Kaijo Sonic, Tokyo, Japan) was placed in front of the mouth of a subject with an optimal angle to the horizontal (Figure 1). Two kinds of airflow were deliberately expulsed by the subject: vigorous blowing for 2 sec and simulated coughing (hawking). The ultrasonic sensor was positioned at 10- and 25-degree angles in blowing and coughing, respectively, which were repeated every 5 sec. Digitalized data for the velocity and temperature of the wind at every 0.05 sec were stored in a personal computer.

Three kinds of masks were compared for airspeed reduction: Mask A, made of cotton gauze (16-ply, weight 10.7 g, price 70 yen); Mask B, of paper (2-ply, 1.2 g, 5 yen); and Mask C, of polypropylene nonwoven fabric (3-ply, 3.8 g, 20 yen).

Figure 2 shows the velocity (red lines) of the wind generated both by blowing (A) and by coughing (B). Compared with the airspeed without masks, all three masks reduced the speed to less than 1/10.

Human influenza is a disease that is transmitted person-to-person with droplets generated by coughing. The virus is stable in a dried condition and considered to also be transmitted by droplet nuclei, which are produced after evaporation of water from the droplets before they fall on the floor. Droplet nuclei are airborne to persons distantly present in the same room (2). If an influenza patient coughs more strongly, not only the droplets carry over a longer distance, but also more droplet nuclei are produced, resulting in more infected persons.

In this study, we found that all the masks examined greatly reduced the wind speed from coughing, implicating that an influenza patient wearing a mask results in fewer new patients. Therefore, when a new influenza pandemic starts, if the majority of coughing patients would use masks, the epidemic expansion would be slowed, which may then minimize chaos in the society and allow enough time for vaccine production.

A worst-case scenario is the occurrence of a 1918 "Spanish"-like influenza. The most striking feature in the pandemic after the 1918 autumn was that many young adults died of alveolitis with massive pulmonary edema (3,4). Experiments in mice infected with the reconstructed 1918 influenza virus have demonstrated viral growth in both the bronchiolar and alveolar epithelial cells and the host's strong cytokine response there; the virus was also shown to propagate in cell cultures in the absence of trypsin (5). If a mutant virus capable of growing in the alveolar cells without trypsin appeared in the fall of 1918, then the patients might have had difficulties in respiration, have coughed more strongly, and produced more droplets than patients infected with strains not growing in the alveoli. The smaller-sized droplet-nuclei generated from the droplets may have flown away in the air and have been inhaled by other persons to their alveoli, where the virus propagated. Such a mutant virus may spread to more persons present at a further distance from the infected individual. Once such a mutant virus appears, it would have higher transmissibility and eventually become the predominant strain in the pandemic. Indeed, if we compare the estimated value of

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the basic reproduction number Ro (the average number of secondary cases generated by one primary case in a susceptible population) for the Spanish influenza (6) with that of the 1957 Asian influenza (7), the former, 2.9, is larger than the latter, 1.7, suggesting a higher transmissibility of the 1918 influenza.

Fig. 1. Measuring the speed of the wind from the mouth with an ultrasonic anemometer. The anemometer/thermometer sensor was placed in front of the mouth. The subject in this picture wore a paper mask.

In the case of a new influenza pandemic, we propose that, as an emergency measure, governments provide free masks to coughing patients who visit health-care providers, and further, to coughing children in schools and to coughing passengers on commuter trains and on domestic/international flights. The masks mentioned above may not protect healthy people from infection because small-sized droplet-nuclei can pass through the masks, but the masks do reduce the spread of the droplets from patients without disturbing their breathing, unlike expensive N95 masks. Lo et al. (8) proposed the stockpiling of masks as part of pandemic planning, particularly in countries with limited resources where antiviral chemotherapy and vaccine production are not feasible. Vugia et al. (9) proposed the use of masks by coughing patients in health-care settings for decreasing influenza transmission. We have shown in this study that even the cheapest paper masks can greatly diminish the airspeed from coughing. The cheaper the masks, the more widely they are used. Providing coughing patients in the general population with such masks costing only 5 yen (about 5 US cents) each at the earliest stage of the pandemic could prevent the worst-case scenario.

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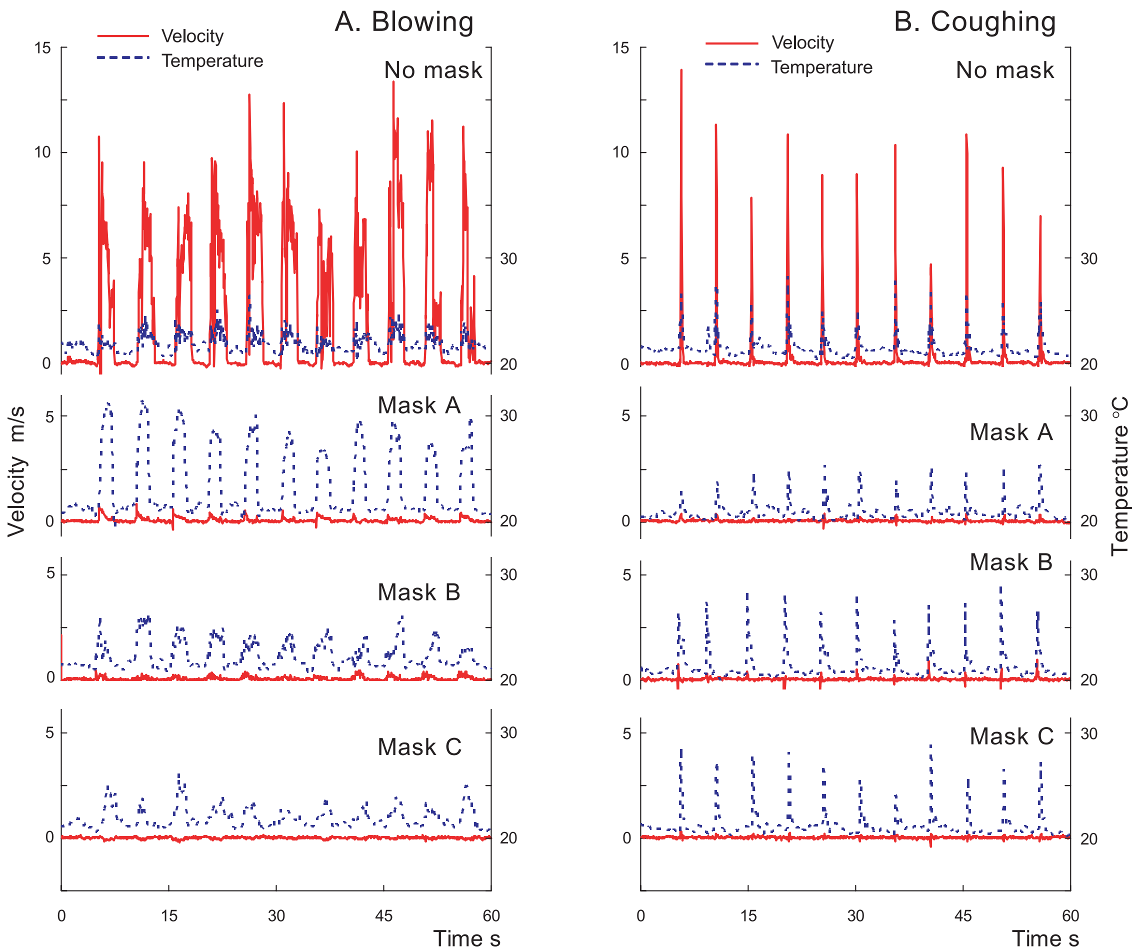

Fig. 2. Reduction of the airspeed by face masks. Vigorous blowing for 2 sec (A) and simulated coughing (B) were repeated every 5 sec. Red lines, airspeed. Dotted blue lines, wind temperature. Mask A, made of 16-ply cotton gauze. Mask B, 2-ply paper. Mask C, 3-ply polypropylene non-woven fabric.

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