Procedure for making a three-layer face mask from low cost, available materials

Jadavpur University, through its Centre for Appropriate Social Technologies (CAST), an Idea Incubation Centre under RUSA 2.0, has taken an initiative to develop a three layer mask from low cost, available materials. As per the mandate of the Government of India, this type of masks are now recommended for every individual to combat against pandemic COVID-19. In the present situation, it is difficult to supply mask to each and every corner of a large country like India. Moreover, the high price of the available masks is a deterrent for a large a section of our population towards the widespread use of masks. Keeping these points in mind, CAST, Jadavpur University tried to develop a simple procedure for making a three-layer mask. The mask can be made using materials readily available in our house or in the neighborhood, which is important since supply of raw materials is an issue in the days of lock-down or even restricted mobility. We ensured that by using these materials, the effectiveness of the mask has not been sacrificed. The process of making is simple enough so that anyone can prepare it of his/her own. At the same time, we paid particular attention to the salient functional requirements of the masks: (i) compared to the N-95 masks (which is strictly recommended for acute patients and the healthcare professionals), the masks are more breathable, so that general people can wear it over longer duration without any serious discomfort; this implies that the pore size is larger than the N-95 filters; (ii) the three layers should be able prevent escape of droplets as the wearer sneezes through it, and at the same time the innermost layer of the mask should remain dry to ensure comfort; (iii) the mask should prevent ingress of droplets from the ambient during inhaling – both through the fabric and the gap between the face and the mask; (iv) the mask could be easily sanitized/disinfected for re-use.

Keeping in view the above requirements, the mask is proposed to be made of three layers of fabric – the innermost, which is in contact with the person wearing it, the intermediate, and the outermost. The innermost and outermost layers are made of a commonly available, nonwoven, polypropylene fabric which has a mildly hydrophobic (water-hating) nature. Presently, we have proposed the clothcarry bags (which are often used as a substitute for plastic bags these days) as a quick option. The intermediate layer is made up of cotton/ cellulosic fibers that are intrinsically hydrophilic (water-loving). A material which we use as a cloth duster or cotton towel (the ubiquitous Bengali *gamchha*). One can use old cotton cloth also for this layer. Figure 1(a) shows the arrangement of the three layers. The combination of the hydrophobic-hydrophilic-hydrophobic layers together allows one-way transport of liquid droplet. Therefore, when the person wearing it sneezes, the droplets shoot past the innermost layer and gets absorbed in the intermediate layer, but its further penetration past the outermost hydrophobic layer is prevented. Also, the innermost hydrophobic layer prevents back-flow of the soaked liquid, keeping the contact surface dry, thus ensuring human comfort and hygiene.

Since the technical specifications of the readily available fabric layers were not available (who would know the porosity and the liquid spreading coefficients of *gamcha*?) and could not be tested by the members of the group working from their homes in the midst of the nationwide lockdown and hence without access to their university laboratory facilities, the most important part of the development was testing three-layer fabric for a real-life situation. A quick, in-house experiment was conducted to verify the effectiveness of the mask in arresting the droplets generated from sneezing of the person wearing a mask. A finely divided spray of water droplets was impacted from close proximity on the innermost polypropylene layer, while any trace of penetration from the outermost polypropylene layer was visually inspected by holding the mask against a mirror-finish surface. The sprinkled water droplets were found to cross the innermost polypropylene layer, keeping its exposed (to the skin) surface dry. The middle cotton layer was found to retain the liquid droplets by wicking (see Fig 1(b)). No noticeable trace of moisture on the mirror-finish test plate was observed on the outermost side, indicating that the second polypropylene layer prevented droplet transmission to its outer exposed surface. Droplet prevention in the reverse flow is also arrested

by the design. When a finely divided mist was incident on the outermost polypropylene layer – this time not with an high impact, since they emulate droplets suspended in ambient air – the droplets could not penetrate the hydrophobic layer. The momentum of the droplets in this case cannot overcome the capillary pressure needed to transport through the pores of the polypropylene layer. Thus, they stay on the outermost surface and eventually evaporate. Hence, the mask is also expected to prevent ingress of airborne liquid droplets during inhaling. It is also verified that a person can breathe normally after wearing this mask. Further quantitative experimentation can be carried out once the University laboratories are accessible.

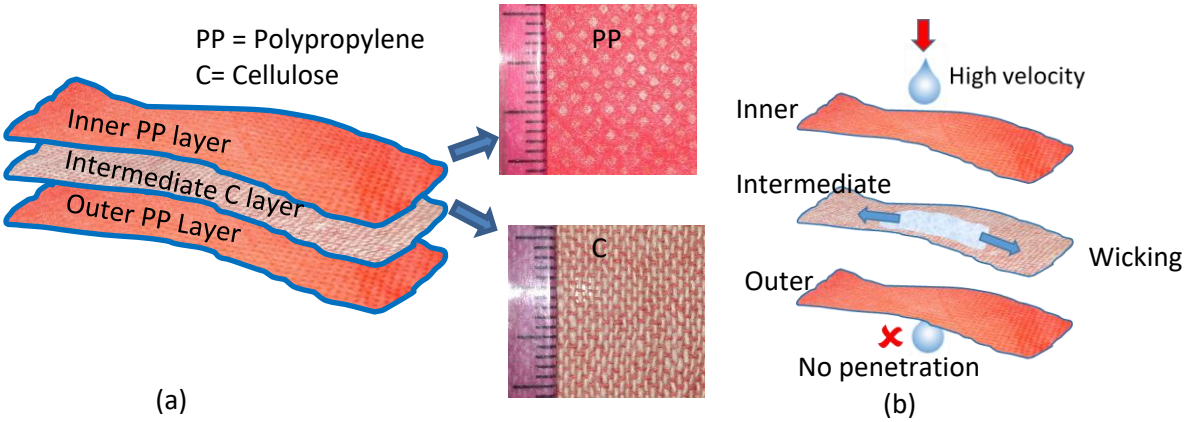

Figure 1: (a) The three-layer structure of the mask, comprising of an innermost polypropyelene (PP) layer, an intermediate cellulosic (C) layer and an outermost polypropylene (PP) layer. Insets show the zoomed-in views of the fabrics. (b) Liquid droplet retention in the three-layer fabric.

Once the three-layer fabric assembly has been prepared by stitching them together, the mask can be made very easily using any suitable mask making template that are available online. We have used one method to make our prototype (see Fig 2). This can be made using a sewing machine very easily. In absence of a sewing machine, it can be hand-stitched also. Care has to be taken while adopting the correct template, so that the mask has the best possible conformity to the face, and the leakage through the gaps and the skin are minimum.

A group of our students has extended their support in this activity. We are preparing videos and write-ups, to disseminate the procedure among the people. On one hand, any organization can take up the procedure to make it and supply; on the other hand any person can make it for his/her own consumption.

Figure 2: (a) Template of the mask (dimensions in cm), (b) the stitched halves, and (c) the final mask.