Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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A study of staff mask contamination on a respiratory admissions ward managing COVID-19 patients reveals concern with infection prevention practice

One aspect of the debate about the use of face masks during the COVID-19 pandemic relates to concerns about mask-wearers potentially contaminating themselves when disposing of used masks (Mantzari et al., 2020). Various air-sampling studies have demonstrated the presence of airborne SARS-CoV-2 in healthcare settings (Chia et al., 2020; Santarpia et al., 2020; Lednicky et al., 2020), which may lead to mask contamination during use.

Here we present data from a small pilot study screening for respiratory viruses (including SARS-CoV-2) on used masks worn by staff on a busy respiratory admissions ward, during the post-first-wave summer trough (August 2020) then the rising surge of second wave COVID-19 cases (October-November 2020) in the UK (Fig. 1).

Standard surgical masks worn mostly in a sessional way were voluntarily donated by ward staff after their daily shifts. Each mask was carefully bagged and labelled in individual, resealable plastic bags and delivered to the testing laboratory. A short, anonymous questionnaire was completed by each mask donor to assess their exposure intensity and workload with potentially SARS-CoV-2-infected patients.

To conserve limited diagnostic reagents, each batch of masks were pooled for swabbing, i.e. one viral swab was used to swab the outside surface of all the masks then a separate swab was used to swab the inside surface of all the masks (Fig. 2). The swabs were collected into tubes containing 1 ml virus transport medium (MWE Ltd., Corsham, England).

The swabbing process consisted of horizontal back and forth sweeping motions with the swab (moistened in virus transport medium) across the middle third of the mask, from top to bottom, four times. All the swab PCR testing was performed using the AusDiagnostics PCR kit (Chesham, Bucks, UK), designed to detect influenza A/B, respiratory syncytial, entero-/rhino-, seasonal corona-, boca-, parainfluenza, adeno-, human metapneumo-viruses, and SARS-CoV-2. Sample RNA extraction was performed using Qiasymphony RNA extraction kit/protocols (Qiagen Ltd., Manchester, UK).

Testing the detection threshold of this method with a Fluenz-Tetra vaccine-spiked mask sample (based on swab sampling, RNA extraction and RT-PCR reaction volumes) indicated that about 30,000 virus RNA copies, accumulated over a 4-hour shift, needed to be present on the mask surface to be detected using this mask-swabbing method. This requires approximately 12–50 viruses/L air impacting on the outer mask surface to allow detection. Data from Ma et al. (2020) (their Table 1) on acute COVID-19 patients, quantitating SARS-CoV-2 in exhaled breath condensates (range: $1.03x10^5$-$2.25x10^7$ viruses/hour, assuming a 10 L tidal minute volume = 600 L/hour, converts to 171–37,500 viruses/L), suggests that this is sufficient sensitivity to detect SARS-CoV-2 impacting on the mask from close-range exposures to acute COVID-19 patients.

Of the 52 masks received for testing, only one batch (n = 8) showed any PCR positive results. This found rhinovirus on both the INTERNAL and EXTERNAL swabs that were taken from all the masks in this batch. This indicates that rhinovirus was present on the inside and outside of one or more of the masks within this batch. All the other batches of masks were PCR negative on both the INTERNAL and EXTERNAL swabs for all targets.

Based on the questionnaires, 52 staff members participated, consisting of 38 doctors, 10 nurses and/or ward support staff, 2 radiographers, 1 medical student and 1 unknown (details not provided). Furthermore, 46 of these staff had no problems wearing the surgical mask during their shift, 6 others complained of the mask causing their glasses to fog, being too tight around the ears, being unable to breathe, giving a dry mouth and throat or an 'electric shock'.

Staff worked across a large open ward area with SARS-CoV-2-zoning and in a number of additional side rooms. Fourteen of these staff saw at least one confirmed COVID-19 patient, 23 were only caring for non-COVID-19 patients, and 15 were managing suspected COVID-19 or non-COVID-19 patients. In terms of potential ward exposure times, 32 staff worked for 4 h or less, 15 worked for more than 4 to 8 h, and 5 staff worked for over 8 h during their shift.

Most of the staff (36/52) wore the mask continuously whilst working, 15/52 declared that they removed their mask just for breaks, and just one staff (a radiographer) stated that they only wore a mask when seeing a patient. Only 2 staff (one doctor and one nurse) stated that they had been involved in an AGP (aerosol generating procedure), the remaining 50 staff were not involved in any AGPs. Finally, the majority of the staff (39/52) stated that they had washed their hands during donning/doffing of their PPE (personal protective equipment), whereas 13 declared that they did not.

The absence of detection of SARS-CoV-2 RNA on any of the mask surfaces may be reassuring to some extent, although the sensitivity of such clinical diagnostic assays are not optimised for environmental samples. Also, findings from environmental sampling usually do not accurately represent the risk of close-range aerosol transmission from infected individuals (Chia et al., 2020; Santarpia et al., 2020; Lednicky et al., 2020; Ma et al., 2020), as dilution and dissemination of airborne virus rapidly dissipates with time and distance from the source (Tang et al., 2014). In addition, mask material is designed to capture and retain airborne particles (Tcharkhtchi et al., 2020), including viruses transported in aerosols ~ 1–100 μm in diameter (Tellier et al., 2019). So the quantitation of viruses from mask surfaces using such surface-swabbing techniques will likely be an underestimate.

Nevertheless, detection of rhinovirus on the inside/outside of one mask suggests that either the wearer was infected with rhinovirus, the secretions of which may have soaked through the mask; or that the rhinovirus was from an outside source, which both contaminated the outer surface and was inhaled around the sides of the surgical mask to

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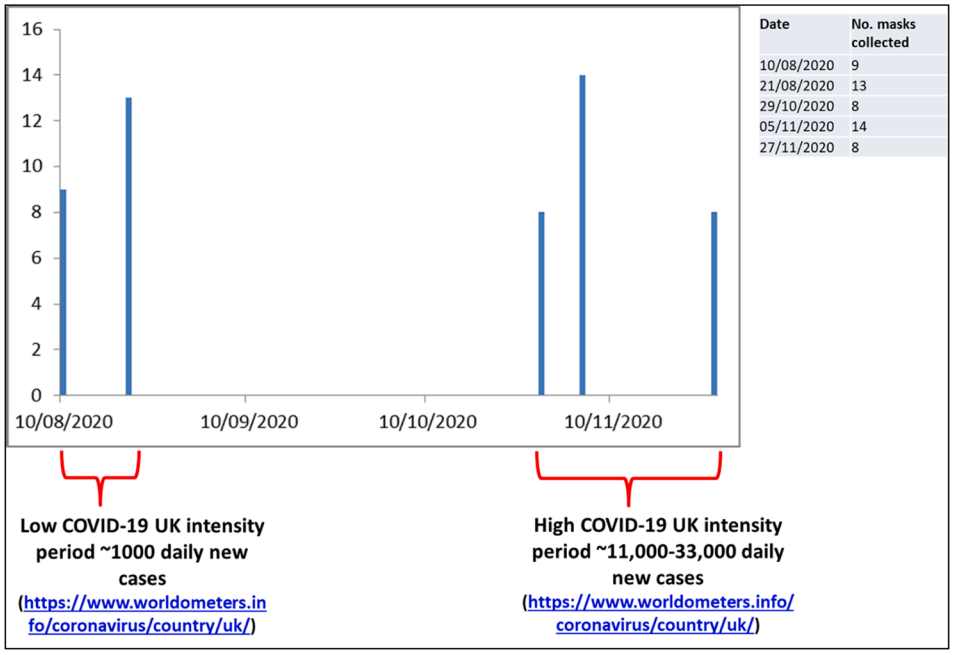

Fig. 1. Mask collection dates and numbers during low (August 2020) and high (October-November 2020) UK COVID-19 intensity periods.

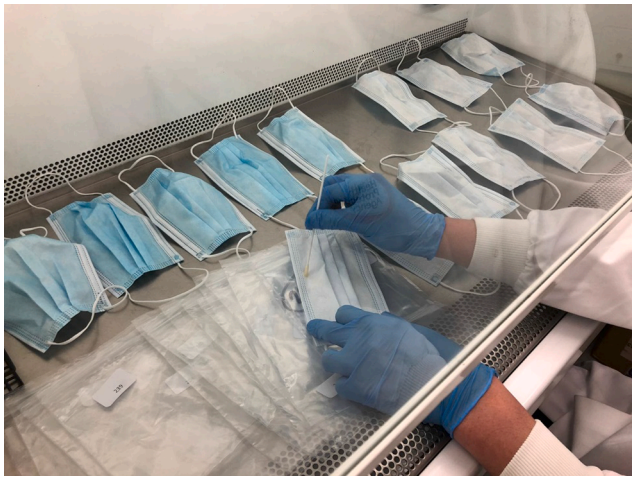

Fig. 2. Mask pooled swabbing process. For each batch of masks, the outer (EXTERNAL) surfaces were all swabbed with one swab to pool any potential viral RNA to enhance the sensitivity of the detection. A similar process was repeated for the inner (INTERNAL) surface of the masks.

contaminate the inner surface. Rhinoviruses have been the only non-SARS-CoV-2 seasonal respiratory viruses that have been detectable during the COVID-19 pandemic (England, 2021), and recent studies suggest that they are also airborne, being able to bypass surgical mask protection to some degree (Leung et al., 2020).

It is encouraging that most staff tolerated the mask-wearing well, with the majority wearing the mask continuously, though some did remove them during breaks. No further detail was collected as to whether this break was taken alone or shared. More concerning was that about 25% of the staff did not wash their hands whilst donning/doffing their PPE. Although self-inoculation via contaminated hands/surfaces is not the main way this virus transmits (https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html), strict hand hygiene should be observed when handling any potentially contaminated PPE.

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