Evidence Base Underpinning Extended Use of N95 Masks

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Current PPE shortages and the resultant need for institutions to implement protocols extending the use of otherwise single-use N95 masks (known technically as filtering facepiece respirators (FFRs)) has put many, myself included, at unease. Will these masks be teeming with viral particles and increase the propagation of disease to the mask user, co-workers, and patients? I sought to understand. What follows is a distillation and citation review of an article [1] published in 2014 by Edward M. Fisher and Ronald E. Shaffer, researchers at NIOSH who sought to describe the evidence base underpinning CDC recommendations on extended use of N95 masks. This a 2-page plain language summary of a 26-page technical article; important details are omitted and editorial comments are inserted.

How much of aerosolized virus will end up on my mask?

When patients with lab-confirmed influenza were asked to breathe into a measuring chamber, the amount of aerosolized virus dropped by 70% if these patients simply wore a facemask [2]. Other physical barriers also decrease viral transfer, such as face-shields (IOM recommendation [3]) or double-masking, although strain/comfort with double-masking are not insignificant. *Takeaway: The degree of viral transfer onto an N95 respirator can be (and should be) mitigated through physical and environmental controls.*

Air samples obtained from rooms of patients with lab-confirmed H1N1 revealed that certain procedures (e.g., bronchoscopy, tracheal intubation) increased the amount (although not statistically significant) of airborne virus [4]. A systematic review of SARS-related retrospective studies confirmed similar findings, with an odds ratio of ~7 for intubations, meaning that the odds of contracting SARS for healthcare workers performing or being exposed to intubation was 7 to 1, relative to healthcare workers not exposed to intubations [5]. Data on nebulized therapies was mixed (pooled estimated odds ratio was 0.9, with substantial heterogeneity among 3 studies). There is no consensus about what constitutes an "aerosol generating procedure" in the context of COVID-19. Neither the CDC [6] nor WHO [7] provide an enumerated list in their clinical guidance. *Takeaway: The amount of airborne virus is increased certain clinical contexts.*

If any virus ends up on my mask, won't I be at risk of infecting myself or others?

While there will always be a non-zero risk (inherent to most aspects of our profession), here is some good news:

(1) Most viral particles are trapped in the middle, not external, surface of the mask. Dissecting influenza-laden masks infected in laboratory settings demonstrated that the 60% of viral particles were present in the middle layer which typically has electrical field-like properties that trap virus there [8]. If you're a visual learner, see the electron micrograph in this reference [9].

(2) The virus dies with time. In studies of a proxy virus for SARS, approximately 15% of viral load survived on the surface of an N95 after two hours in room air; approximately 0.1% lingered after 24 hours [10].

(3) Even if you touch your mask, not much virus gets transferred to your hands. No direct study has looked at viral transfer specifically from N95-to-hand, but we know that laboratory viruses do not like porous surfaces. Transfer efficiency (amount of virus from a given surface that is transferred to a fingertip after 10 seconds of contact) were very low when tested on both cotton (0.03%) and polyester (0.3%) [11]. And I hope you are wearing gloves anyway.

(4) Even if you cough, not much virus is transferred back into the air. During simulations of forceful cough (i.e., applying standardized pressures from the inside of the mask outward), at most 0.2% of mask's viral load was re-aerosolized [9].

Takeaway: SARS-CoV-2 would need to get from the infected patient to the air, through a physical barrier, land on the mask, remain on the N95's outer surface, survive on the N95's outer surface, and be successfully transferred to your hand, or back into the air, to potentially cause infection. There is a substantial and incremental decrease in transmissibility potential with each of these steps.

Will prolonged use impact the mask's ability to protect me, in terms of filtration or fit?

When masks were blasted (literally, with flow rates of 85 L/m) for 5 straight hours of continuous particle loading, filtration efficiency remained >97%. This was specifically tested with particles < 200nm (coronavirus = 120-160 nm) [12]. N95 means they are rated to filter out 95% of airborne particles.

Additionally, the fit test is a good test. Simulation of three 10-min patient encounters (obtaining vital signs, wound dressing change, IV care) demonstrated that initial mask-fit was predictive of mask-fit during care tasks [13].

However, fit can decrease with each re-use. When lab participants were asked to don/doff masks 20 times consecutively (keeping the N95 on for 2 minutes each time), there was decreasing mask fit with each re-use, with only 60% passing fit test on the 20th use [14]. This is one of the reasons "extended" use (keeping it on) is recommended over "re-use" (on/off/on). Another reason is the donning/doffing process requires a seal check each time, meaning that your (gloved) hands need to touch the mask more with each re-use.

Can I endure wearing a mask for most of my work-day/shift?

Physiologically, yes. After an hour of low/moderate treadmill exercise, healthy young adults exhibited limited change in vital signs when wearing N95 compared to doing same exercise without a mask. There was no significant change in RR; no change in SpO2; 2-3% increase in tCO2 (40 vs 42); and 10 bpm increase in HR (114 vs 124) [15]. In a separate study, there was no difference in core body temperature after 2 hours of work, but there was a 1°C increase in cheek temperature inside the mask [16]. (Caveat: I'm unaware of related studies on older adults or those with comorbid conditions, including asthma).

Psychologically, it can be difficult. 60% of 27 VA workers could not complete 8 hours of continuous N95 use (with 3 interspersed regulated breaks) due primarily to discomfort and difficulties communicating [17]. Another study showed that 9 of 10 ICU RNs could use the mask for two full 12h shifts. Observers following them around noted masks were usually taken off every 2-3 hours for a break, and the mean number of touches-to-mask per shift was up to 15 [18].

Overall,
N95 respirators have a number of technical features which, alongside the implementation of administrative and environmental controls, may mitigate the potential for respiratory viral disease propagation during extended use. There is solid scientific base of evidence underpinning CDC current guidelines, albeit the majority of which is based in laboratory experiments rather than real world observations. Decontamination strategies may further decrease the infection potential arising extended use of N95 respirators, but such efforts may inadvertently also pull resources away from an already constrained system.