EDITORIAL

Sourcing Personal Protective Equipment During the COVID-19 Pandemic

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As the coronavirus disease 2019 (COVID-19) pandemic accelerates, global health care systems have become overwhelmed with potentially infectious patients seeking testing and care. Preventing spread of infection to and from health care workers (HCWs) and patients relies on effective use of personal protective equipment (PPE)—gloves, face masks, air-purifying respirators, goggles, face shields, respirators, and gowns. A critical shortage of all of these is projected to develop or has already developed in areas of high demand. PPE, formerly ubiquitous and disposable in the hospital environment, is now a scarce and precious commodity in many locations when it is needed most to care for highly infectious patients. An increase in PPE supply in response to this new demand will require a large increase in PPE manufacturing, a process that will take time many health care systems do not have, given the rapid increase in ill COVID-19 patients.

Editorial

In its current guidance to optimize use of face masks during the pandemic, the Centers for Disease Control and Prevention (CDC) identifies 3 levels of operational status: conventional, contingency, and crisis.[1] During normal times, face masks are used in conventional ways to protect HCWs from splashes and sprays. When health care systems become stressed and enter the contingency mode, CDC recommends conserving resources by selectively canceling nonemergency procedures, deferring nonurgent outpatient encounters that might require face masks, removing face masks from public areas, and using face masks for extended periods if feasible.

When health systems enter crisis mode, the CDC recommends cancellation of all elective and nonurgent procedures and outpatient appointments for which face masks are typically used, use of face masks beyond the manufacturer-designated shelf life during patient care activities, limited reuse, and prioritization of use for activities or procedures in which splashes, sprays, or aerosolization are likely. When face masks are altogether unavailable, the CDC recommends use of face shields without masks, taking clinicians at high risk for COVID-19 complications out of clinical service, staffing services with convalescent HCWs presumably immune to SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), and use of homemade masks, perhaps from bandanas or scarves if necessary.

Many communities in the US and globally are rapidly entering crisis mode. Popular news outlets report unconventional solutions for PPE at local hospitals, such as plastic garbage bags for gowns and plastic water bottle cutouts for eye protection.[2] Plans for resupply through the repurposing of industrial capacity and other means are welcome but seem unlikely to solve the shortage quickly enough as supply chains become more dysfunctional in the pandemic.[3] The Department of Health and Human Services' Strategic National Stockpile was created to solve precisely this problem, but its inventory is not transparent and news reports suggest its supplies are being distributed unevenly or are insufficient to meet demand.[4]

HCWs need supplies and solutions for these shortages now, and for that reason *JAMA* issued a call for ideas for how to address the impending PPE shortage.[5] In the week since publication the article received more than 100 000 views and generated more than 250 comments. In addition, many additional ideas were sent directly to *JAMA* editors. The **Box** organizes the major themes of the contributions and the following discussion reviews several of them.

A frequent proposal was to acquire PPE from existing supplies in non-health care industries and settings such as construction, research laboratories, nail salons, dentists, veterinarians, and farms, and redirect them to the health care system via charitable appeals, community organizing, financial incentives, or government mandate. One endeavor is Project N95, a national COVID-19 medical equipment clearinghouse to identify high-need regions and to source and distribute PPE and other equipment where it is needed most.[6]

Numerous proposals suggested sterilization of used PPE with agents ranging from ethylene oxide, UV or gamma irradiation, ozone, and alcohol. There were also novel proposals such as mask-fiber impregnation with copper or sodium chloride. These are not new ideas; work was performed after prior viral epidemics to determine the feasibility of sterilizing PPE.[7] Most commenters acknowledged uncertainty about the effects of these sterilizing agents on the structural integrity of PPE, and there is some evidence the fibers in masks and respirators that filter viral particles can degrade and lose their efficacy with PPE reprocessing.[7]

A few people advocated for use of positive pressure airflow helmets; proposals ranged from creating devices from plastic bags insufflated using compressed air and nasal cannula tubing to adoption of commercially available devices used in the welding industry. An advantage of this approach is that by not relying on filters, positive airflow devices can be cleaned and reused indefinitely.

Many proposals reflect an era when PPE was made of cloth and laundered.[8] Health care might be made greener if reusable PPE was employed where feasible. Cloth gowns and masks are easily created and stored, and laundry capacity could easily be expanded by recruiting commercial launderers that service hotels and other large organizations who currently sit idle. Many contributors wrote of sewing masks, creating them out of clothing, using novel materials to make them, and using cloth

Box. Summary of Recommendations for PPE Conservation and Management

Import
Purchase from international suppliers: China proposed as a primary market given manufacturing capacity, experience with and decline in COVID-19 incidence

Reclaim
Dentists, farmers, construction, high schools, universities, veterinarians, salons, manufacturing, aerospace, industrial "clean labs"
- Individual HCW procurement in towns and communities
- Charitable movements
- Public or private buybacks
- Public or private bounties

Reuse
Rotate through 72-h cycles given current understanding of surface viability

Reusable elastomeric respirators (have exchangeable filter cartridges)

Disinfectants
- Heat (eg, autoclave), UV, ozone, ethylene oxide, hydrogen peroxide, bleach, isopropyl alcohol, gamma or e-beam radiation, microwave, copper sulfate, methylene blue with light, sodium chlorine, iodine, zinc oxide impregnation (gowns), hypochlorous acid, commercial laundering (for cloth)

Repurpose
Prefabricated masks: snorkel and scuba, 3D printed, welder's, civilian military grade gas masks, ski buffs

Eye and face shields: sports eye protectors, motorcycle helmets with visors, balaclavas

Gowns: plastic ponchos or poly bags, bedbug sheet material

Adhesive bandage as nasal PPE

Create supply
Sewn fabric masks and gowns, coffee filter masks, home HVAC filter masks

Extend supply
Plastic face shields (water bottle cutouts, thermoplastic sheets, A4 acetate sheets, Ziploc bags) to preserve face masks and eyewear

Reduce nonessential services
Cancel elective and ambulatory procedures; reduce questionable contact and isolation precautions (eg, MRSA/VRE, influenza, cellulitis)

Reduce patient contact
Utilize mobile and out-of-room monitoring and device controls, e-consults, extended dwell IVs, batching medications or self-administration, barrier visits

Alter staffing
Reduce student and trainee patient contacts

Use nonhuman services
Nonhuman services (drones and robots) for delivery of test kits for self-testing, robots for equipment movement within hospitals, decontamination protocols

Stratify use by patient risk
Cohort patients and reduce PPE use for those at low risk (ideally requires testing to accurately stratify low and high risk)

Employ immune workers
HCWs recovered from clinical illness or with demonstrated immunity care preferentially for COVID-19 patients without PPE

Use government solutions
Regionalize care and supply, import international supply, ration supply, loosen import regulations, commandeer business to accelerate supply

Manage supply
Reduce bulk packaging, Pyxis-like controlled distribution, nongovernment regional coordination of PPE distribution

Miscellaneous
Convert RV trailers to negative pressure spaces; phase change material to improve comfort and reduce reuse of gowns

Abbreviations: COVID-19, coronavirus disease 2019; HCW, health care worker; HVAC, heating, ventilating, and air-conditioning; MRSA, methicillin-resistant *Staphylococcus aureus*; PPE, personal protective equipment; VRE, vancomycin-resistant Enterococcus.

sleeves to extend the use of N95 respirators. As with resourced material, most commenters acknowledged uncertainty about the ability of these handmade solutions to filter infectious agents and weather repeated cleaning, although common sense suggests they are better than no PPE at all.

High-grade filters used in respirators such as N95 devices exist in many commercial products. Some ideas involved creating masks from air-conditioning filters or vacuum cleaner bags. These plentiful and commercially available household antiallergen filters have a MERV (minimum efficiency reporting value) rating for their filtering efficiency of 13 or 14, meaning they will reduce the flow of particles larger than 0.3 µm by 50% or 75% respectively. N95 respirators are 95% efficient for these particles and equivalent to a MERV 16 filter. Although the SARS-CoV-2 particle is smaller than 0.2 µm, the water droplets carrying it are larger and largely blocked by these filters. Several commentators suggested using snorkel masks and tubes, which are easily cleaned and reused, and could efficiently use home-sourced filter material placed on the end of the tubing for added protection.

Conservation of existing PPE is important, as recommended by the CDC. Some commenters called for suspending practices that consume large amounts of PPE and are of uncertain effectiveness, such as contact precautions for some infectious diseases, to free up supplies.[9,10] The idea of using HCWs who have recovered from clinical illness or who have stayed healthy but test positive and are presumed immune and are no longer infectious is an age-old and appealing solution. Hoarding of PPE and other supplies has occurred during the current COVID-19 pandemic, and some proposals suggested rationing or controlling the supply chain through limited, controlled allocation of supplies, a Pyxis-like administration system or regional coordination, for example.

These and scores of other comments are insightful, many have references, provide links to websites and videos with illustration and instructions, and readers should spend time

determining which, if any, might best fit their needs and situations. But the ingenuity displayed in the contributions needs to be placed in context. First, few of the ideas can be successful independent of the broader health care enterprise and its vulnerabilities. The commonly suggested process of cohorting low-risk patients for PPE preservation, for example, requires rapid testing to be accurate and efficient, a requirement regrettably not yet met in most US health systems. More important, PPE shortages are a problem for HCWs, but not a problem HCWs are trained to address or should be expected to solve; it's become cliché to point out that firefighters are not asked to source their own equipment before entering burning buildings. Hospital administrators, health system media relations departments, university leadership, elected officials, and government agencies have a role to play in reaching out to suppliers and organizing a response and develop a reliable supply system. Hospitals successful at procuring supplies should employ rational use of PPE. Better-resourced institutions and some clinician advocates have considered policies requiring all staff to wear face masks in public spaces regardless of high-risk exposures, despite little evidence that this is a judicious use of resources.

JAMA will continue to offer commenting on COVID-19 articles so that clinicians may share their experiences and ideas regarding how to best get through the COVID-19 crisis. When health systems pass this stress test, the operations, organizations, and profession will have learned a thing or two, and be stronger for it.

ARTICLE INFORMATION

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