

Navigating Healthcare Supply Shortages During the COVID-19 Pandemic: A Cardiologist's Perspective

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Circulation 2020

<https://doi.org/10.1161/CIRCOUTCOMES.120.006801>

The powerful infectivity of the SARS-CoV-2 virus has led to over 1 million infections worldwide and forced more than half the world's population to live under stay-at-home orders. To respond to this deadly infection, healthcare workers desperately need personal protective equipment, medical supplies such as ventilators, and pharmaceuticals. However, virtually every country in the world is seeing severe shortages of these healthcare supplies at a time of maximal need. As cardiologists, we have the opportunity to see how we can change our clinical practices to respond to these healthcare supply shortages. To determine how we can approach these important issues, we first need to understand how healthcare supplies are delivered and how COVID-19 has disrupted this system. The provision of healthcare supplies occurs because of a robust international supply chain that provides timely delivery to healthcare systems around the world.¹ Supply chains consist of producers of raw materials, manufacturing factories, transportation systems, and distribution networks.² Disruptions to these supply chain networks have occurred in the past, but they have been “single deletions” such as losing a source of raw material, an isolated factory closing, or turmoil in a single country.² Because the supply chains are international and matrixed, they are usually self-healing in response to these isolated incidents. Supply chains also work to optimize alignment between the volume of healthcare supplies delivered and the demand in healthcare facilities. Because of this supply chain optimization, most healthcare systems and even entire nations keep only a modest inventory of healthcare supplies in anticipation of future demand.² Today, however, the COVID-19 pandemic has disrupted the healthcare supply chain worldwide. Shortages of raw materials are universal which have led to dramatic increases in prices. For example, the price of isopropyl alcohol used in hand sanitizers has gone up from ~\$1000 to \$3160 per metric ton.³ Infections in Lombardy Italy surrounded one of the key worldwide factories that produce nasopharyngeal swabs to test for the SARS-CoV-2 virus.⁴ The pandemic has disrupted transportation networks with the shutting down of international flights worldwide and restrictions in cross-border travel and shipping. Sixty-eight countries have limited the export of their personal protective equipment supplies to other countries further breaking down the distribution networks of the international supply chain.⁵ Since the pandemic has impacted virtually every country worldwide, there are no unaffected reservoirs of industrial activity to draw from. This supply chain disruption would have been normally challenging, but an explosion in the demand for healthcare supplies has made the situation much worse. COVID-19 patients requiring hospitalization must be placed in infectious isolation with extensive use of personal protective equipment. One estimate showed that a COVID-19 patient’s 24-hour intensive care would require 36 pairs of gloves, 14 gowns, 3 pairs of goggles, and 13 N95 face masks.⁶ Typically, a hospital would have a very small number of patients requiring this intensity of personal protective equipment. However, hospitals in COVID-19 hotspots have now found over 100% of their beds being used for treating this infection leading to an explosion in the need for personal protective equipment. The current monthly requirement for the N95 respirator mask has been estimated at 300 million in the United States in the face of domestic production of only 35 million by a major manufacturer.⁷ As of April 1, 2020, national predictions included a need for 31,782 ventilators in the United States.⁸ The need for pharmaceuticals involved in the treatment of acute respiratory illness and intensive care has also exploded. In March 2020, national orders for albuterol, midazolam, and fentanyl have increased by 53%, 70%, and 100%, respectively.⁹ In New York City, the increases for these three drugs have been 1,870%, 533%, and 4,100%, respectively. The increase in demand for healthcare supplies has outstripped all existing inventories with even the Strategic National Stockpile being reported as nearly empty.¹⁰ The combination of supply chain disruption with exploding demand forces healthcare organizations to manage healthcare supplies to maximize benefits for patients and healthcare workers while also ensuring the sustainability of these resources. If the situation is not addressed properly, healthcare supply shortages threaten patient care delivery and compromise the safety of healthcare workers. Thus, cardiologists need to follow a principled and systematic approach to manage this

challenging and dynamic situation (Table 1). In a pandemic, one of the first actions is to reduce the non-essential utilization of healthcare supplies in coordination with government and regulatory agencies. For example, in coordination with healthcare facilities, the state of Ohio stopped all non-essential surgeries on March 18, 2020.¹¹ Essential procedures include those that meet the following criteria: (1) threat to the patient's life if surgery or procedure is not performed, (2) threat of permanent dysfunction of an extremity or organ system if not performed, (3) risk of metastasis or progression of staging and (4) risk of rapidly worsening to severe symptoms. For cardiologists, examples of essential procedures include primary PCI for STEMI, cardiac surgery for symptomatic valvular heart disease, and pacemakers and defibrillators for syncope and prevention of sudden death. Nonessential procedures can include appropriately screened patients for diagnostic cardiac catheterization and intervention in stable ischemic heart disease, cardiac surgery for asymptomatic valvular heart disease, and ablations for mildly symptomatic atrial fibrillation. By doing so, substantial reductions can be achieved in patient protective equipment, ventilators for elective surgery, and critical pharmaceuticals. To ensure proper utilization of limited healthcare supplies, organizations should create guidelines on utilization based on expert guidance, local utilization patterns, and local supply levels. These guidelines need to be transparent and widely visible and also need to be dynamic as they may need to change. Once these guidelines are established, organizations can determine their anticipated future utilization rates and match them to their supplies in quantitative predictive models. Cardiologists should ensure alignment with these local guidelines to support the overall strategies to ensure the long-term viability of healthcare supplies. At the state and national level, similar predictive models can allow governments to understand their population's needs.⁸ All predictive models should be understood as estimates with planning created around a range of possible outcomes. Patient care delivery must change in the face of pandemics to minimize utilization levels of healthcare supplies and to support the front-line caregivers. Cardiologists should organize their teams to minimize redundant patient contact. They should evaluate the need for laboratory evaluations, diagnostic testing, and patient in-hospital travel to minimize the use of personal protective equipment and healthcare worker exposure. The need for electrocardiograms and echocardiograms should be examined and clear guidelines should be set to ensure that these tests create true clinical value.¹² Virtual telehealth can also now be used to protect caregivers from exposure given very favorable regulatory and payment policies from the Centers for Medicare and Medicaid Services. Cardiologists are now free to use many common mainstream video technologies to meet patients, collaborate with front-line clinicians, and review imaging studies remotely. Extending the use of healthcare supplies from single-patient use to multiple uses can help reduce consumption rates. Traditionally, personal protective equipment has been recommended to be only for single-patient use and then discarded. In the COVID-19 era, this practice would lead to unsustainable consumption rates of personal protective equipment. Some hospitals place their patients with COVID-19 in one unit to allow healthcare workers to use one set of personal protective equipment all day. Providing healthcare workers with a set of equipment for an extended period for reuse has also been done although it is not without controversy. There is a concern for self-inoculation and also nosocomial transmission with continued use. Also, standards for how long personal protective equipment can be reused and how it can be kept uncontaminated are not well studied. Similarly, strategies to use ventilators for two patients have been proposed and approved as a last resort by the Department of Health and Human Services.¹³ Recycling of personal protective equipment through sterilization protocols affords another opportunity to increase the supply of this equipment. Healthcare organizations have begun to collect personal protective equipment in anticipation of reuse opportunities. The Batelle Corporation has created a Critical Care Decontamination System using hydrogen peroxide to sterilize N95 respirators.¹⁴ One of these devices can sterilize 5000 N95 masks in 2.5 hours and can resterilize masks up to 20 times. These units received emergency Food and Drug Administration approval and have been deployed in multiple cities in the United States. Although impossible to fully plan for in advance, cardiologists must be prepared for dramatic changes in their roles in locations with overwhelming COVID-19 infection. Healthcare worker infections can lead to loss of cardiology personnel and staffing plans should be created to respond to these situations. Strategic staffing models should be designed with both vertical integration (i.e. how would one hospital respond) and horizontal integration (i.e. how would multiple hospitals share limited resources). Cardiologists may need to eliminate nearly all cardiology services other than emergency care and transfer the remaining cardiovascular patients to non-COVID-19 hospitals.¹⁵ These steps would create resources for COVID-19 patients, consolidate services, and protect cardiac patients from

the risk of infection. Finally, as the pandemic progresses, cardiologists may be called to provide direct care to COVID-19 patients because of their skills in taking care of hospitalized patients. Training in ventilator management and basic critical care refresher courses can help with this transition.¹⁶ In addition, cardiologists must be aware of unique issues surrounding the rationing of healthcare supplies which will become evident. Unfortunately, in a pandemic situation, the protocols for healthcare supply management can easily be overwhelmed leading to a lack of sufficient healthcare supplies. The absence of effective personal protective equipment can be catastrophic as healthcare workers become infected leading to personal risk of mortality, disruption in the healthcare workforce, and also the risk of nosocomial transmission. In Spain, a very high burden of the disease combined with challenges with personal protective equipment has led to 15,000 healthcare workers being infected making up 14% of the total COVID-19 case burden.¹⁷ In these situations, there are no clear guidelines on actions that healthcare workers can take to continue to protect themselves. Several innovative but unvalidated techniques have been proposed including using ski goggles for eye protection, masks made from automotive cleaning cloths, and plastic barrier protections to protect healthcare personnel when providing the high-risk procedure of endotracheal intubation.^{18–20} In settings with limited ventilators and pharmaceuticals, cardiologists will face ethically difficult allocation decisions and will need to review and establish criteria with intensivists to decide who will not receive care. Early in the pandemic, the Italian College of Anesthesia, Analgesia, Resuscitation and Intensive Care highlighted that “allocation criteria need to guarantee that those patients with the highest chance of therapeutic success will retain access to intensive care”.²¹ Concerns regarding the impact of these decisions on vulnerable populations have led to the HHS Office of Civil Rights to caution against using age or disability as sole factors in determining the allocation of limited resources.²² University of Pittsburgh researchers have proposed a model that integrates the risk of short-term mortality with the benefits of long-term survival to serve as a balanced approach in these complex circumstances.²³ Even when well thought out, these decisions will remain a heart-wrenching part of clinical care during the COVID-19 pandemic. In response to a life-threatening viral infection, the human immune system creates an immediate response to fight the infection but also creates antibodies to support long-term protection from future reinfection. Healthcare systems are now fighting the infection’s immediate impact on supply chains and healthcare care supplies. Once the current COVID-19 pandemic is conquered, it is imperative for healthcare systems, members of the healthcare supply chain, and governments to create resilient systems to protect against a future viral pandemic attack on our healthcare supply chains.