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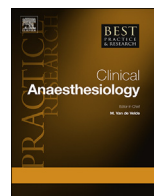


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Economic impact of COVID-19 pandemic on healthcare facilities and systems: International perspectives



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International hospitals and healthcare facilities are facing catastrophic financial challenges related to the COVID-19 pandemic. The American Hospital Association estimates a financial impact of \$202.6 billion in lost revenue for America's hospitals and healthcare systems, or an average of \$50.7 billion per month. Furthermore, it could cost low- and middle-income countries ~ US\$52 billion (equivalent to US\$8.60 per person) each four weeks to provide an effective healthcare response to COVID-19. In the setting of the largest daily COVID-19 new cases in the US, this burden will influence patient care, surgeries, and surgical outcomes. From a global economic standpoint, The World Bank projects that global growth is projected to shrink by almost 8% with poorer countries feeling most of the impact, and the United Nations projects that it will cost the global economy around 2 trillion dollars this year. Overall, a lack of preparedness was a major contributor to the struggles experienced by healthcare facilities around the world. Items such as personal protective equipment (PPE) for healthcare workers, hospital equipment, sanitizing supplies, toilet paper, and water were in short supply. These deficiencies were exposed by COVID-19 and have prompted healthcare organizations around the world to invent new essential plans for pandemic preparedness. In this paper, we will discuss the economic impact of COVID-19 on US and international hospitals, healthcare facilities, surgery, and surgical outcomes. In the future, the US and countries around the world will benefit from preparing a plan of action to use as a guide in the event of a disaster or pandemic.

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Introduction

One year ago, the 7.5 billion people on the Earth would not have predicted the enormous impact of COVID-19. According to the World Health Organization (WHO), the first identifiable case of COVID-19 was discovered in December 2019 in the Wuhan province of China, and the disease was declared a global emergency on January 30, 2020. However, many experts believe that the virus spread unnoticed throughout the region many months before that [1]. The single-stranded RNA virus spreads through aerosol droplets and can cause lethal respiratory complications. Preliminary studies by the CDC estimate that this novel strain of the Coronavirus has an infectivity, also known as R_0 (R-naught), of 2.5, meaning that one infected individual would, on average, spread the virus to 2.5 noninfected individuals [2]. In comparison, the common influenza virus has a R_0 of ~1 each year. With a vaccine expected in 2021 and no effective treatment to combat the virus, the world has endured the devastating effects of COVID-19. One of the most notable global effects that was seen during the infancy of the pandemic was the disruption of the global supply chain. (see Fig. 1)

Covid-19 is projected to be the United States' third leading cause of death in 2020; the pandemic is expected to cause a 3.3 trillion dollar deficit in 2020, which is about 15% of the United States' GDP [3]. Over 51% of Americans have reported a loss of employment income since the pandemic started, along with an unemployment rate that skyrocketed to 14.7 when the pandemic started [4]. With lost wages and employment, Americans have been struggling throughout the year to make rent and mortgage payments, especially young adult Americans. The young adult demographic of America, especially minorities, are the most vulnerable to these economic effects due to not having time to accrue capitol

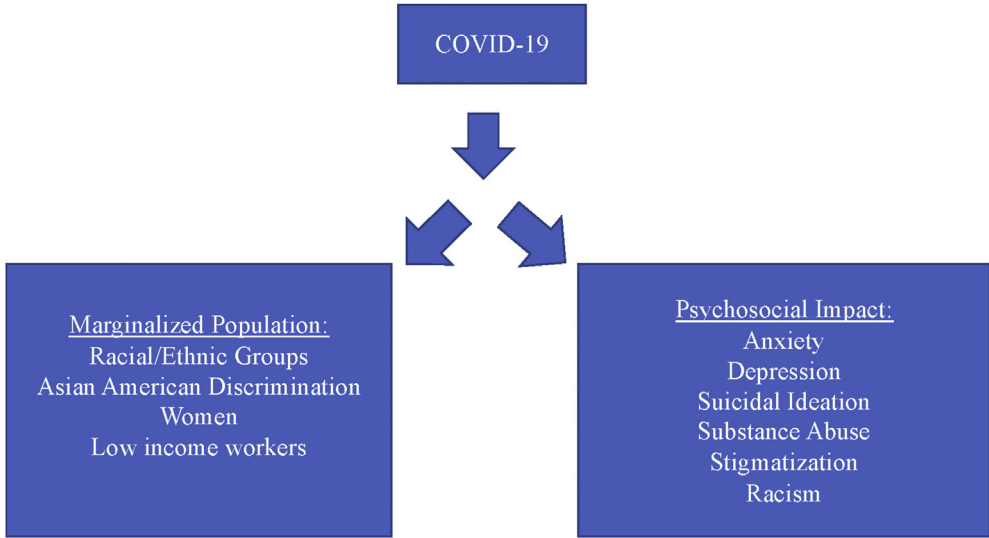


Fig. 1. COVID-19: Impact on marginalized population and psychosocial implications: [8,9,12].

to withstand an economic standstill. Current studies project that 1 in 5 American renters will become evicted in 2020 with a higher probability in people with a socio-economic disadvantage [5].

Covid-19 also impacted international affairs. COVID-19 originated in China, and China is responsible for 12.2% of the world's total exports; therefore, many countries immediately lost access to vital goods once the Chinese government implemented a mandatory quarantine. Many countries, especially poor countries, have heavily relied on China for many of their societal needs, and this dependence was exposed by COVID-19. Unfortunately, some of these lost vital goods included extremely important items to combat the virus, such as facemasks, respirators, pharmaceutical medicines, and other various raw materials. As a result, the lack of a Personal Protective Equipment (PPE) in certain countries propagated the viral spread and only exacerbated the pandemic. From a global economic standpoint, The World Bank projects that global growth is projected to shrink by almost 8% with poorer countries feeling most of the impact, and the United Nations projects that it will cost the global economy around 2 trillion dollars this year [6]. This paper will discuss the impact that Covid-19 has had on the United States and on international healthcare systems.

Impact on the United States

Marginalized population

Based on the National Collaborating Centre for Determinants of Health, marginalized populations are defined as “groups and communities that experience discrimination and exclusion (social, political and economic) because of unequal power relationships across economic, political, social and cultural dimensions” [7]. During this pandemic, this definition of marginalized populations has never been more accurate. In the United States, the COVID-19 pandemic has had a detrimental and negative impact on marginalized communities. This includes (1) the disproportionate negative impact on racial/ethnic groups, (2) increased anti sentiment toward Asian Americans, (3) negative effect on women, and (4) negative impact on low-income workers [8].

COVID-19 seems to have disproportionately affected low-income workers. Similarly, ethnic/racial groups seem to have been disproportionately affected compared to Caucasians. Many economic sectors have been negatively impacted; however, the continued insults to industries such as personal services,

transportation, bars/restaurants, retail, and manufacturing appear to be significant drivers. This is because a large component of these industries comprises marginalized groups such as African Americans, Latino communities, Native Americans, and women. This has led to a disproportionate impact on minority groups and women. Compounded with the fact that Latin groups and African Americans have historically had higher unemployment rates and decreased wages than Caucasians, it is essential to know this. These populations are much more vulnerable to COVID-19's economic impact [8].

Since the onset of COVID-19, there has been a concerning rise in racial discrimination toward Asian Americans. This can be cited from a report by the Asian Pacific Policy and Planning Council, which had received an astonishing 1497 reports of discrimination within the first eight weeks alone. Interestingly, over 50% of these reports came from 2 states experiencing the most impact, New York and California. Furthermore, the Global Market Research and Public Opinion (IPSOS) had administered a survey in the US, showing that nearly 30% of American citizens attribute the COVID-19 pandemic to China. Additional study results also found that almost 30% of participants had witnessed others blame Asians for causing COVID-19. Indeed, these findings are concerning as COVID-19 has introduced further discrimination if not exacerbated this phenomenon toward a population that experienced discrimination before the pandemic [8].

COVID-19 has significantly impacted women for several reasons. Women are often involved in multiple essential roles, including work, family, household, and caretaking responsibilities, compared to men. Although there is a balance amongst these responsibilities, the COVID-19 pandemic has certainly disrupted this. Because daycares and schools have closed due to the pandemic, children stay at home, and thus, women have been taking on more responsibilities within the household than men. For women who work from home, this can lead to additional stress as managing both home responsibilities and work can be challenging. Given the disparity in wages between women and men, the woman may just choose to focus less on work responsibilities in the context of abruptly have increasingly essential duties, including childcare and education. Women who work in the service industry may significantly be affected due to social distancing. Women who are essential workers also face challenges as they may be required to return to work even though there may not be adequate support for childcare at home. Because of work expectations, societal expectations, wage differences between men and women, and a rapid rise in household responsibilities, women may be under much stress than before the pandemic [8].

Low-income frontline works have also been affected by the COVID-19 pandemic. One particular example are employees at grocery stores. Although considered an essential service, these employees are amongst the lowest wage earners at \$11.37 per hour with little or no access to protective equipment nor healthcare benefits. The Latino population is heavily employed at grocery stores, and thus, COVID-19 has disproportionately impacted the Latino community. This is a detrimental situation as some grocery store workers must experience the pressure of having to risk their own physical/mental health versus earning a wage that may already be low or inadequate. Indeed, because grocery stores are essential, there must be further efforts to help those who are working at low-income front line jobs [8].

Psychosocial impact of COVID-19

The COVID-19 pandemic has caused a tremendous psychosocial disparity amongst the population of the United States. It has caused panic, fear, anxiety, uncertainty, and mass hysteria. In this section, we will discuss the psychosocial impact COVID-19 has had on the United States [9,10].

Since the onset of COVID-19, there has been a negative psychological impact in the United States. Disorders involving anxiety and depression have been on the rise since the onset of the pandemic. A survey conducted by the Centers for Disease Control (CDC) saw that at least 40.9% of participants experienced at last one adverse mental health condition. This included symptoms related to increase substance abuse, anxiety, depression, suicidal ideation, trauma-and stressor-related disorders. Approximately 25% of participants in the survey who reported suicidal ideation were between the ages of 18 and 24. This survey also revealed a disproportionate negative psychological impact on African Americans, Hispanic populations, unpaid caregivers for adults, individuals with preexisting psychiatric conditions, and essential workers. The survey's overall results had shown that there was an overall increase in suicidal ideation, substance abuse, and mental health conditions in June 2020 in the United States [10].

The psychosocial impact of COVID-19 is akin to the SARS outbreak in 2003, especially regarding stigmatization. Healthcare workers associated with treating SARS patients were at a higher risk of stigmatization. Similarly, healthcare workers treating COVID 19 patients can be subjected to this phenomenon. Stigmatization can provoke discrimination and marginalization, leading to victims feeling stereotyped, treated differently, heightened suspicion, and feel the loss of status [9,11]. Indeed, this is concerning as stigmatized groups can lead to unhelpful behavior such as seeking medical care late, which can lead to a higher probability of spreading the virus [9]. Healthcare professionals are at a higher risk of stigmatization [9].

Self-quarantine is the first recognized method to prevent the spread of COVID-19. Although it is one of the primary preventive measures to manage this virus, it is not without its issues. Quarantine and isolation have inadvertently led to its negative psychosocial impacts on the community. It has led to extreme anxiety and distress as well as a bad feeling of losing control. Exacerbating factors include loss of finance, a decreased supply of basic essentials, and possibly a worsening false sense of contracting the disease. Further isolation can lead to symptoms similar to obsessive compulsiveness as individuals may have extreme anxiety about their health. This can lead to excessive adverse behaviors, such as cleaning and checking temperatures repeatedly [9].

Healthcare and frontline workers have been affected by this pandemic and are considered high-risk groups for adverse psychological effects [9]. This is due to several factors: (1) high risk of exposure to COVID-19, lack of personal protective equipment, sudden increase and prolonged work hours, being a part of significant ethical and emotional taxing decision-making, and fears of infecting their loved ones. In addition to this, healthcare workers must isolate themselves from loved ones, further exacerbating adverse psychological insults. These psychological stressors can lead to anxiety and depression. It has been suggested that if healthcare providers seek out psychological treatment, it includes a psychosocial assessment to monitor for insomnia, substance abuse, domestic violence, anxiety, and depression, amongst others. These findings are highly concerning as healthcare professionals indeed risk their health to treat others. Still, we as a community must open further dialog to shed light on mental health in frontline workers [12].

Social media has exacerbated the negative psychosocial impact of COVID-19. Soon after the onset of COVID-19, information on social media regarding COVID-19 was on the rise as misinformation and possibly fear-mongering had spread out of control. Rumors, propaganda, and increased false information on multiple social media platforms lead quickly to increased panic, anxiety, and hysteria. Unfortunately, social media has also been a tool for discrimination against the Chinese community. Given misinformation about food habits, cultural norms, and disparaging comments through social media has exacerbated negative attitudes toward the Chinese community. Social media has been wrought with misinformation and has led to further racism, discrimination, and hysteria [9].

The psychosocial implications of COVID-19 can be detrimental. Panic, fear, anxiety, uncertainty, depression, and other adverse psychological issues can result from this. There must be more dialog and continued effort to treat these psychosocial effects of COVID-19, especially amongst vulnerable populations [9,10].

Impact on USA healthcare facilities

To prepare for a surge in hospitalized patients with COVID -19, hospitals needed to create more negative pressure rooms, hire a backup workforce, pay overtime to staff, educate staff, obtain PPE, and address PPE shortages. All nonemergent and elective surgeries and procedures were canceled to free up essential hospital staff and hospital beds. Social distancing practices and patient anxiety related to COVID-19 led to the cancellation of nearly all outpatient appointments and a transition to virtual telemedicine appointments [13,14]. With increased costs related to COVID-19 and the lost revenue from the cancellation of outpatient office visits, elective procedures, and elective surgeries, hospitals throughout the country became financially strained [14].

Academic medical centers were particularly stressed in the United States. They have taken on a significant amount of debt within the last few decades as they have worked to improve and expand their clinical facilities. While incurring this debt, academic medical centers have functioned as a safety

net healthcare system in the US while also pursuing different academic missions, making them one of the most expensive healthcare systems in the US, with relatively low operating margins [15]. This pre-pandemic economic vulnerability combined with a reliance on clinical income to maintain cash flow caused these institutions to be disproportionately affected by COVID-19.

Veterans Affairs hospitals faced many of the same problems; however, their financial impact was less severe, given their ability to run as a highly coordinated, nonprofit national medical center. Physicians in mostly elective and/or procedural-based specialties working within the VA had fewer financial concerns regarding lost revenue in the face of canceled procedures, as they did not participate in a fee-for-service business model like their private-sector counterparts. Also, because the VA functions as a national system, the agency could alter its supply chain to route the appropriate equipment and PPE to the areas that were hit hardest by the pandemic. Nationally, the VA contributed 16,500 acute care beds, 3000 ventilators, 1000 isolation rooms, and 4000 deployable disaster emergency volunteers to aid the American public [16]. The VA converted much of its outpatient visits to virtual telehealth appointments. This process was very efficient and streamlined within the VA since they had used telehealth for years and employed the first chief telehealth officer in 1999. The VA anticipated the large expansion in virtual care that would occur with the coming pandemic. Soon after the first COVID-19 cases were identified in the US, they began to invest in the necessary resources and equipment that were needed to ensure an appropriate technological infrastructure was in place, including loaning patients tablets, and delivering equipment for remote monitoring such as pulse oximeters, thermometers, and smartphones [17].

During the pandemic there was a concerted effort to protect nursing home patients, who are among the most vulnerable patients in our society. Early in the pandemic, one nursing home cluster infection in Washington state demonstrated how rapidly infection could spread. On February 28, an employee at the nursing home was diagnosed with COVID -19. On that day, at least 45 residents and staff at the facility had symptoms of respiratory illness. By March 18, there was a total of 167 confirmed cases of COVID-19 affecting 101 residents, 16 visitors, and 50 employees. Subsequently, 54% of residents and 50% of the staff were hospitalized, with a 33% case fatality rate for the residents [18].

Nursing homes and long-term care facilities have been overwhelmingly impacted by COVID-19, with more than 40% of the total deaths related to the pandemic being residents or staff of these facilities. Eight out of ten COVID -19 deaths in the US occur in individuals older than 65. Therefore, approximately \$5 billion dollars was allocated to long-term care facilities and state veteran's homes through the Coronavirus Aid, Relief, and Economic Security (CARES) Act. This funding supported enhanced infection control measures, increased testing, hiring of additional staff, and providing additional services to residents such as technology that allows nursing home residents to connect with their families during times when outside visitors to these long-term care facilities are restricted [19].

Global impact

China

China was the original epicenter of the pandemic after the first cases were reported in Wuhan in December 2019. Within a month, the Chinese government instituted a strict lockdown of Hubei, the province in which Wuhan is located. Travel within the city of nearly 9 million residents was severely restricted as busses, subways, and ferries came to a standstill. All transport into and out of the city and province was prohibited as the airports and train stations were closed. Throughout the rest of China, similar but less restrictive limitations were imposed on inter and intra-city travel [20,21]. While these measures were effective in controlling the spread of the virus, they were not without consequences. China saw its GDP shrink by 6.8% in the first quarter of 2020, the first decline in almost 30 years [22]. Additionally, the strict lockdowns proved costly to the mental well-being of many residents [20]. China lifted the last of its lockdowns in April 2020, and the rest of the world is watching eagerly as the country continues to trend toward some semblance of normalcy [23]. See [Table 1](#).

Table 1
Real Gross Domestic Product (GDP), annual percent change.

	2019	Projected ^a	
		2020	2021
World	2.9	−4.9	5.4
United States	2.3	−8.0	4.5
China	6.1	1.0	8.2
India	4.2	−4.5	6.0
Brazil	1.1	−9.1	3.6
ASEAN-5	4.9	−2.0	6.2
Low-Income Developing Countries	5.2	−1.0	5.2

^a Projections from the International Monetary Fund. Adapted from [38].

India

The first case of COVID-19 in India was reported on January 30, 2020, in Trissur, Kerala. Originally, the country employed a strategy focused on containment of the virus, applying measures such as quarantine of individuals traveling from high transmission areas, isolation of infected individuals, contact tracing, and restricting the travel of people from areas where caseloads were high. As the number of cases increased, the contribution of sustained local transmission to the propagation of the virus became evident, and focus shifted to mitigation measures as a means of tackling the virus [24]. Similar to the procedures implemented in China, India enforced bans on public gatherings, air travel both within the country and internationally, and the closure of public places [24,25]. These restrictions put pressure on an economy that was already sluggish, and immediate negative impacts were seen in the agricultural, manufacturing and service sectors. Indian exports were hit significantly as the virus spread within the countries with which India conducts trade, and those countries halted manufacturing [26]. Furthermore, the pandemic and resultant lockdowns have taken a large psychological toll on many in India, exacerbating symptoms of anxiety and depression. Suicide has been observed in some battling addiction due to the inability to procure addictive substances [25]. As the pandemic rages on across the world, and some measure of lockdown persists in parts of the country, the ultimate impact of COVID-19 in India remains to be seen.

Brazil

COVID-19 did not reach Brazil until late February 2020, but it quickly became a global hotspot. In contrast to the mandates issued by the federal governments of other countries, Brazil lacked a national response to the virus; instead, interventions were implemented by individual States/Federative Units (FU) [27,28]. President Jair Bolsonaro drew widespread criticism for his seeming insouciance toward the virus. He often spoke out against lockdowns imposed by FUs, effusively promoted the unproven treatment hydroxychloroquine, and expressed a general disregard for the gravity of the pandemic [29]. The lack of consistent messaging from the government added a layer of complexity to a fight that would have already been challenging. Roughly 13 million Brazilians live in crowded favelas with limited access to clean water, making adherence to physical distancing and hygiene guidelines near impossible [28].

As in other parts of the world, the pandemic has had a profound effect on Brazil's economy. From March 9 to 13, the São Paulo stock market dropped just over 15%, its worst weekly drop since the 2008 financial crisis. Furthermore, GDP fell 11.4% in the second quarter of 2020 as compared to the previous year [29,30]. As of September 2020, Brazil had over 4 million confirmed cases and 125,000 deaths, trailing only the United States in total cases and making the country 6th globally in deaths per capita [31].

Singapore

Singapore's response to the pandemic has been extolled as one of the most successful in the world. With the first cases appearing in December 2019, the country was one of the earliest to report COVID-19 and initially was second only to China in total cases. The SARS-CoV outbreak of 2002 exposed many

shortcomings in Singapore's ability to deal with pandemics and was the impetus for the country to shore up those weaknesses. The country established the National Centre for Infectious Diseases (NCID) and 900 rapid response to public health preparedness clinics (PHPCs). Regular exercises were held to simulate the arrival of a pandemic. As a result, Singapore was well equipped to perform mass screening of potentially infected individuals. They also established themselves as one of the most prolific in testing and contact tracing. The National University of Singapore (NUS) Yong Loo Lin School of Medicine developed an engaging series of comics entitled "COVID-19 Chronicles", that provide important information pertaining to the virus in a format that is easily understood by most demographics. Messages such as these have been widely disseminated throughout the country and have garnered international acclaim.

Additionally, Singapore utilized many tactics similar to other countries that experienced outbreaks, such as limiting the size of gatherings, encouraging physical distancing, restricting travel, and screening and quarantine those entering the country. Strict penalties were imposed for violating these guidelines. Interestingly, Singapore did not initially resort to issuing a formal lockdown or closing schools until a flare-up of cases led to a 21-day order on April 28, 2020. This was several months after the virus was first detected in the country [32,33]. Despite the country's success in controlling the infectious burden of the virus, due to the interconnectedness of the global economy, Singapore was not spared the economic impact of the pandemic as the country reported a 13.2% contraction in GDP in the second quarter of 2020 as compared to the previous year [34].

Effects on low- and middle-income countries

The challenges posed by the pandemic in middle- and low-income countries (LMICs) are perhaps the most daunting. Longstanding obstacles such as limited access to healthcare, extensive poverty, high prevalence of comorbid disease, limited access to clean water, and densely packed slums are amplified by the arrival of COVID-19. These realities make the implementation of practices such as social distancing, frequent hand washing, and mass testing virtually impossible, and without support, these countries are at risk for devastating consequences. Furthermore, many residents of LMICs cannot afford to miss work for any amount of time, and many of the economies are not equipped to withstand significant lockdowns [35,36].

It is often said that when the United States or China sneezes, the rest of the world catches a cold. Indeed, the effects of lockdowns and the resultant economic downturns in larger economies have trickled into the economies of LMICs. For example, between April and May of 2020, remittances fell by 18 percent in Bangladesh and by 39 percent in the Kyrgyz Republic, compared to the previous year. Remittances account for a relatively significant portion of GDP in some LMICs, and many impoverished families are dependent on them for survival. The hurdles to control the spread of the infection, coupled with the ripple effect from the faltering of the global economy face LMICs with overwhelming odds. Fortunately, many LMICs acted swiftly to contain the spread of infection by enacting measures such as school closure, restrictions on public gatherings, and travel [37]. Moreover, many in the international community have recognized the need to provide aide to these countries and are attempting to do so [36,37].

Impact on global healthcare facilities

The fallout from COVID-19 has impacted nearly every facet of the economies of most countries throughout the world, not the least of which has been the healthcare sector, which has been met with monumental challenges in trying to cope with and respond to the pandemic. A lack of preparedness was a major contributor to the struggles experienced by healthcare facilities around the world. In many instances, personal protective equipment (PPE) for healthcare workers was in short supply. One study found that only 37.4% of Pakistani healthcare workers had access to N95 respirators, 34.5% to gloves, 13.8% to face-shields or goggles, and 12.9% to full suits/gown [39]. These numbers were even lower in Jordan, where according to one study, only 18.5% of doctors reported having access to all necessary PPE [40]. Even the United States, a country whose healthcare system is often associated with seemingly unlimited access to medical supplies, was not immune to PPE shortages. Nearly 15% of doctors reported

that they did not have access to N95 respirators, over 20% lacked access to gloves, approximately 12% did not have access to face shields, and roughly 50% did not have full suits/gowns available to them. Furthermore, approximately 7% of physicians reported being forced to care for COVID-19 patients without proper PPE, and over 80% reported reusing elements of PPE [39]. Many healthcare facilities throughout the country resorted to calling for donations of PPE from the community, and resourceful citizens devised creative ways to fashion PPE from household items. Similarly, healthcare facilities around the world experienced widespread shortages of ICU beds and ventilators. Globally, most healthcare facilities did not have the capability to test extensively making it difficult to identify and isolate infections. These shortages were exacerbated as lockdowns around the globe disrupted supply chains.

The management of non-COVID-19 illness has become a casualty of the intense focus on fighting the pandemic. A WHO survey of 155 countries found that prevention and treatment services for non-communicable diseases (NCDs) have been severely disrupted since the COVID-19 pandemic began. As the virus continued to spread, healthcare workers who typically dealt with NCDs were reassigned to support the COVID-19 response. Furthermore, in accordance with the guidelines of many public health organizations, procedures and appointments that were not deemed to be urgent or emergent were postponed. Decreases in the availability of public transport presented challenges for many to travel to their scheduled appointments. This meant that patients with serious illnesses such as cancer, diabetes, and cardiovascular diseases were often not able to receive the services and medicines that they required. Unsurprisingly, these effects were most pronounced in low-income countries as they were forced to devote already sparse resources to fighting the pandemic [41]. A study of seven slums in Bangladesh, Kenya, Nigeria, and Pakistan revealed reduced access to services such as antenatal and immunization programs, screening for hypertension, tuberculosis, HIV, and vector-borne disease; all of which commanded significant attention prior to the pandemic. Moreover, the cost of healthcare increased while household incomes decreased [42]. Encouragingly, the deficiencies exposed by COVID-19 have prompted healthcare organizations around the world to come up with new ways to ensure that essential care does not have to be delayed or withheld during this pandemic or in any similar circumstance in the future. Alternative strategies such as telemedicine have quickly taken hold in healthcare facilities globally and are helping to offset the toll that the pandemic has taken on the care of NCDs [41–43].

Surgical considerations

The COVID-19 pandemic has had a profound impact on the global economy, but, as we see a decline in new cases in several countries, the Canadian Society of Cardiac Surgeons has provided guidelines to mitigate further financial loss in cardiac surgery centers [44]. They term these guidelines “a ramp-up”, which includes gradually increasing the number of elective cardiac surgical procedures while, of course, following all local public health mandates. Experts hope this cautious return to normalcy will mitigate some of the catastrophic economic burden of COVID-19 on cardiac surgical centers. From the perspective of trauma and orthopedic surgery, a team from Germany conducted a national online cross-sectional survey among trauma and orthopedic surgeons, which acknowledged the “severe financial constraints” of the pandemic on these two surgical specialties [45]. Unsurprisingly, self-employment was identified as an independent positive predictor of financial stress, a variable in which the study’s multiple regression model termed “depletion”. Based on the multiple regression model results, the authors conclude that additional support should be offered to self-employed trauma and orthopedic surgeons, as they are disproportionately financially affected by the pandemic. Similar to their cardiac surgeon counterparts, this group agrees that the cessation of elective procedures played a significant role in the pandemic’s economic burden on their specialties. Looking at this group’s statistical analysis in further detail, it appears that specialized trauma and orthopedic surgeons were less concerned about financial loss than non-operative orthopedic physicians. The results demonstrated that 30% of participants felt as if they might be forced to stop practicing due to the pandemic, and 63% would appreciate more financial support from the country’s health insurance providers. However, a silver lining presents itself in the form of telemedicine—44% of participants expected its value to increase in the future. Of course, the extenuating circumstances in which the survey was

developed leaves many questions about its psychometrics. In an editorial published in the “Aesthetic Surgery Journal”, a successful Swedish plastic surgeon revealed a 29% loss in revenue over one month at his 22-year-old private practice during the pandemic [46]. He also reported a 100% loss in revenue at a private practice he opened in Italy two years before the pandemic. Authors of this article attribute this tremendous financial adversity to international government ban on elective surgeries- for those plastic surgeons who have decided to exclusively practice in the aesthetic field, this means their practice is now effectively banned in most countries- “...terrible and possibly irreversible damage to our livelihoods...”. Lastly, a collaboration between US-based and Latin American healthcare teams describes the first-ever effort to highlight COVID-19's significant economic impact on Latin American radiation oncology therapy services [47]. Survey results from 15 Latin American countries (including Argentina, Aruba, Costa Rica, among others) revealed that less than 3% of radiation oncology centers closed during the pandemic, and estimated revenue reduction was at least 20% in over half the centers. Researchers distributed the American Society for Radiation Oncology (ASTRO) survey across Latin America to elucidate the pandemic's economic impact in a region of the world where radiation oncology is an already chronically neglected field of healthcare. This team also highlighted telemedicine's promise in the future of Latin American radiation oncology.

Effective risk reduction strategies

Effective risk reduction strategies to prevent airborne and contact transmission of the novel coronavirus SARS-CoV-2 requires a system safety approach factoring in viral sensitivities, strategies for environmental bioburden reduction, disinfection practices, ventilation controls, and human factors. Pre-symptomatic and symptomatic individuals prolifically shed the virus in diverse arrays of droplets and aerosols. The virus is contained in varied mixtures of organic material and bodily fluids comprising the droplets and aerosols. The size and density of the expelled viral-laden mixtures affect the distance traveled. Particles with high densities deposit on nearby objects or person(s). Finer viral-laden fluid droplets comprise aerosols that suspend and travel in the air currents aided by ventilation-derived flow patterns. Viral longevity is time dependent on the level of protection milieu maintained by the enveloping organic capsule [19].

The first step in reducing COVID-19 transmission risk is minimizing infective bioburden release into work, break, and lavatory environs. This is accomplished first by keeping ill and potentially infected person at home to the extent possible. Wearing masks consistently reduces the volume and degree of projected release of infectious viral-laden bioburden, providing significant risk reduction to the wearers' co-workers. The personal benefit of masks accrues from its barrier function, both preventing unconscious hand movements from reaching the mouth's mucous membranes and large and medium-sized droplets from others. NIOSH-rated N95 masks and eye protection, glasses shields or goggles, or air-filtered full-face masks provide the best protection from airborne CoV-19. These must be readily available to all staff, particularly those with risk factors associated with severe adverse outcomes from CoV-19 infections.

COVID-19 particles can be rendered noninfectious by typical agents classified as effective low-level disinfectants by the Centers for Disease Control. These typically are 50–60% alcohol-based liquid gel mixtures. These approved products slow the evaporation of the alcohol component; thus, there is sufficient effective contact time with the viral particles. Concentration and contact time are important factors. Alcohols in water alone are less effective since the alcohol component evaporates quickly to reduce the actual alcohol content to concentrations that require progressively longer contact times that are not achieved [16].

Intact skin provides protection from viral penetration but not from transfer to mucous membranes. Thorough handwashing with soap and water at the start of the day reduces the infective bioburden transported in from the outside from contact with contaminated surfaces and suspended droplets and aerosols. Frequent use of approved hand gels after patient care or contact with potentially contaminated surfaces should be compulsively routine. This reduces the risk of infecting oneself by rubbing your mouth, nose, or eyes with contaminated hands. It also reduces the risk of transferring infective bioburden to workspace areas such as desktops, computer keyboards, “mouse” and touchscreens.

Workplace surfaces, including drawer handles and doorknobs/bars, should be wiped down with high disinfectants at regular intervals depending on the frequency of use and number of staff sharing the equipment. Engineering controls such as plastic covers over computer keypads are easier to effectively clean and prevent liquids from damaging the underlying electronic interfaces. Maintaining containers of disinfectant cloths and gel dispensers in work areas at the point of use are visual cues to aid in compliance with safety disinfection practices.

HVAC-related engineering controls can reduce the aerosolized CoV-19 infective bioburden. High room air volume exchange rates above 6–12 air volume exchanges/hour and the use of appropriately sized HEPA air filtration reduces infective aerosol content and promotes desiccation of moisture envelopes of deposited and suspended viral droplets. Signage indicating the airflow patterns allow staff to choose to congregate near HVAC fresh air inflow vents and avoid HVAC air return vents where aerosol content is higher.

Break rooms used by staff for coffee breaks and meals and bathrooms present unique challenges. Lower air volume exchange rates allow aerosols to persist longer. Masks are removed during meals. This facilitates increased release and transmission of infective droplets and aerosols from contagious individual(s). Multiple high-frequency touch surfaces, including refrigerator and microwave door, handles, coffee pot and cabinet door handles, and tabletops. Cleaning supplies should be readily available, and their use should be encouraged by signage. Bathroom high touch surfaces by hands should be cleaned frequently. If high-use bathroom air volume exchange rates are low, propping bathroom doors open when not in use should be considered.

Human factor considerations need to be emphasized. Fatigue is a human condition that degrades performance of routine and complicated tasks. Depending on cognitive work intensity and physical demands, performance degrades after several hours and substantially after 12–16 h. Compliance with infection control paradigms and recommended behaviors are expected to decline with fatigue. This increases the risk for disease acquisition by the individual and those sharing the workspaces.

Organizational controls can have a large impact. Random work assignments maximize the potential exposure of others by a single infectious asymptomatic individual. Consistent teams' assignments should be considered to the extent possible to reduce cross infectivity among large groups of staff, as suggested in a modeling study by Mascha et al., where they propose a one week on-one week off shift schedule to decrease employee exposure and prevent work burnout [48]. Prevention of burnout can also be complimented by considering personality type when selecting leaders to direct groups of workers and when comprising the groups of workers. Individuals with emotional intelligence, also known as the ability to empathize with peers and control one's emotions, is a desirable personality trait that can cultivate an environment for success among workers [49].

Best work practices include wearing high-quality masks, social distancing as much as possible, surveillance testing based on community positivity rates, contact tracing, and post-exposure isolation until antigen tests are negative after a reasonable post-exposure interval and well-considered cleaning paradigms should be the norm.

Conclusion

As the COVID-19 pandemic continues to spread through many parts of the world, it is leaving in its wake a devastating trail of destruction. Aside from the rising number of cases and deaths, a consequence that is reasonably expected, the virus has had an insidious effect on economies around the world. Following the declaration of COVID-19 as a pandemic in March 2020, global commerce came to a virtual halt as restrictions were imposed on travel, and people around the world took heed of social distancing guidelines that encouraged them to stay in their homes as much as possible. China was the original epicenter of the pandemic after the first cases were reported in Wuhan. From there, the virus spread to many countries including the United States, India, Brazil, Singapore, and disproportionately affected low- and middle-income countries and individuals. A lack of preparedness was a major contributor to the struggles experienced by healthcare facilities around the world. In many instances, PPE for healthcare workers was in short supply. Encouragingly, the deficiencies exposed by COVID-19 have prompted healthcare organizations around the world to invent new essential care for patients. Alternative strategies such as telemedicine, social distancing, mask-wearing, handwashing, and

quarantining have all helped decrease the effects of the COVID-19 pandemic and will likely influence healthcare for the foreseeable future.

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Practice points

- Best work practices include wearing high-quality masks, social distancing as much as possible, surveillance testing based on community positivity rates, contact tracing, and post-exposure isolation until antigen tests are negative after a reasonable post-exposure interval and well-considered cleaning paradigms.
- The psychosocial implications of COVID-19 can be detrimental. Panic, fear, anxiety, uncertainty, depression, and other adverse psychological issues can result from this.
- Alternative strategies such as telemedicine have quickly taken hold in healthcare facilities globally and are helping to offset the toll that the pandemic has taken on the care of non-communicable diseases.
- Compliance with infection control paradigms and recommended behaviors are expected to decline with fatigue, potentially increasing the risk for disease acquisition by the individual and those sharing the workspaces.

Research agenda

- Investigate the value of telemedicine in reducing infection rates while maintaining the highest quality of care
- How operational deficiencies exposed by COVID-19 have prompted healthcare organizations around the world helped invent new essential care for patients.
- Assess the economic impact of COVID-19 on US and international hospitals, healthcare facilities, surgery, and surgical outcomes.

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References

- [1] He X, Lau EHY, Wu P, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat Med* 2020;26: 672–5. <https://doi.org/10.1038/s41591-020-0869-5>.
- [2] Li Q, Guan X, Wu P, et al. Early transmission dynamics in wuhan, China, of novel coronavirus–infected pneumonia. *N Engl J Med* 2020;382:1199–207. <https://doi.org/10.1056/NEJMoa2001316>.
- [3] Heron M. *National vital statistics reports volume 68, Number 6, June 24, 2019, deaths: leading causes for 2017. 2019.*
- [4] CBO's current projections of output, employment, and interest rates and a preliminary look at federal deficits for 2020 and 2021 | Congressional budget office. 2020. <https://www.cbo.gov/publication/56335>. [Accessed 25 October 2020].

- [5] Riley ED, Hickey MD, Imbert E, et al. COVID-19 and HIV spotlight the U.S. imperative for permanent affordable housing. *Clin Infect Dis* 2020. <https://doi.org/10.1093/cid/ciaa1327>.
- [6] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese center for disease control and prevention. *JAMA - J Am Med Assoc* 2020;323:1239–42. <https://doi.org/10.1001/jama.2020.2648>.
- [7] Marginalized populations. *Natl Collab Cent Determ Health* 2020.
- [8] Cots JM, Alós J, Bárcena M, et al. 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. 2020.
- [9] Rasmussen Sonja A. Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-. *Ann Oncol* 2020;19–21. <https://doi.org/10.1007/s00134-020-05991-x>. Bizzarro.
- [10] Czeisler MÉ, Lane RI, Petrosky E, et al. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic — United States, June 24–30, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1049–57. <https://doi.org/10.15585/mmwr.mm6932a1>.
- [11] Is W, Stigma S. Social Stigma associated with COVID-19 A guide to preventing and addressing 2020:1–5.
- [12] McGowan ML, Norris AH, Bessett D. Care churn - why keeping clinic doors open isn't enough to ensure access to abortion. *N Engl J Med* 2020;383:508–10. <https://doi.org/10.1056/NEJMp2013466>.
- [13] Barnett ML, Mehrotra A, Landon BE. Covid-19 and the upcoming financial crisis in health care. 2020. <https://doi.org/10.1056/CAT.20.0153>.
- [14] Satiani B, Davis CA. PRACTICE MANAGEMENT the financial and employment effects of coronavirus disease 2019 on physicians in the United States 2020. doi:10.1016/j.jvs.2020.08.031.
- [15] Colenda CC, Applegate WB, Reifler BV, et al. COVID-19: financial stress test for academic medical centers. *Acad Med* 2020; 95:1143–5. <https://doi.org/10.1097/ACM.00000000000003418>.
- [16] The best health system to react to COVID-19 - the American. 2020. <https://prospect.org/coronavirus/the-best-health-system-to-react-to-covid-19/>. [Accessed 24 October 2020].
- [17] Heyworth L, Kirsh S, Zulman D, et al. Expanding access through virtual care: the VA's early experience with Covid-19 2020. doi:10.1056/CAT.20.0327.
- [18] McMichael TM, Currie DW, Clark S, et al. Epidemiology of covid-19 in a long-term care facility in King County, Washington. *N Engl J Med* 2020;382:2008–11. <https://doi.org/10.1056/NEJMoa2005412>.
- [19] Sullivan-Marx E. Aging in America: how COVID-19 will change care, coverage, and compassion. *Nurs Outlook* 2020;68: 533–5. <https://doi.org/10.1016/j.outlook.2020.08.013>.
- [20] Gan Y, Ma J, Wu J, et al. Immediate and delayed psychological effects of province-wide lockdown and personal quarantine during the COVID-19 outbreak in China. *Psychol Med* 2020;1–35. <https://doi.org/10.1017/S0033291720003116>.
- [21] Yuan Z, Xiao Y, Dai Z, et al. Modelling the effects of wuhan's lockdown during covid-19, China. *Bull World Health Organ* 2020;98:484–94. <https://doi.org/10.2471/BLT.20.254045>.
- [22] PwC CN. *China economic quarterly Q1 2020*. 2020.
- [23] Normile D, Cohen J, Enserink M, et al. As normalcy returns, can China keep COVID-19 at bay? Infected travelers pose a continuing threat, but local coronavirus transmission still occurs as well. *Science* (80-) 2020;368:18–9. <https://doi.org/10.1126/science.368.6486.18>.
- [24] Varghese GM, John R. COVID-19 in India: moving from containment to mitigation. *Indian J Med Res* 2020;151:136–9. https://doi.org/10.4103/ijmr.IJMR_860_20.
- [25] Kaur S, Sonali S. India fights COVID-19. *Psychol trauma theory. Res Pract Policy* 2020;12:579–81. <https://doi.org/10.1037/tra0000615>.
- [26] Rakshit B, Basishtha D. Can India stay immune enough to combat COVID-19 pandemic? An economic query. *J Public Aff* 2020. <https://doi.org/10.1002/pa.2157>.
- [27] Garcia LP, Duarte E. Intervenções não farmacológicas para o enfrentamento à epidemia da COVID-19 no Brasil. *Epidemiol e Serv Saude Rev Do Sist Unico Saude Do Bras* 2020;29:e2020222. <https://doi.org/10.5123/S1679-49742020000200009>.
- [28] The Lancet. COVID-19 in Brazil: "so what? *Lancet* 2020;395:1461. [https://doi.org/10.1016/S0140-6736\(20\)31095-3](https://doi.org/10.1016/S0140-6736(20)31095-3).
- [29] Brazil hits 4 million Covid cases while life gets back to normal - Bloomberg. 2020.
- [30] Melo CMLD, Silva GAS, Melo ARS, et al. COVID-19 pandemic outbreak: the Brazilian reality from the first case to the collapse of health services. *An Acad Bras Cienc* 2020;92:e20200709. <https://doi.org/10.1590/0001-3765202020200709>.
- [31] COVID-19 Deaths Per Capita by Country | Statista. 2020.
- [32] Kuguyo O, Kengne AP, Dandara C. Singapore COVID-19 pandemic response as a successful model framework for low-resource health care settings in Africa? *OMICS* 2020;24:470–8. <https://doi.org/10.1089/omi.2020.0077>.
- [33] Lee VJ, Chiew CJ, Khong WX. Interrupting transmission of COVID-19: lessons from containment efforts in Singapore. *J Travel Med* 2020;27:1–5. <https://doi.org/10.1093/jtm/taaa039>.
- [34] Singapore Releases Second-Quarter 2020 GDP, Economic Data. 2020.
- [35] Shuchman M. Low- and middle-income countries face up to COVID-19. *Nat Med* 2020;26:986–8. <https://doi.org/10.1038/d41591-020-00020-2>.
- [36] Bong CL, Brasher C, Chikumba E, et al. The COVID-19 pandemic: effects on low- and middle-income countries. *Anesth Analg* 2020;131:86–92. <https://doi.org/10.1213/ANE.0000000000004846>.
- [37] COVID-19: without help, low-income developing countries risk a lost decade – IMF blog. 2020.
- [38] World Economic Outlook Update. *Int Monet Fund* 2020.
- [39] Ahmed J, Malik F, Bin Arif T, et al. Availability of personal protective equipment (PPE) among US and Pakistani doctors in COVID-19 pandemic. *Cureus* 2020;12:e8550. <https://doi.org/10.7759/cureus.8550>.
- [40] Suleiman A, Bsisu I, Guzu H, et al. Preparedness of frontline doctors in Jordan healthcare facilities to COVID-19 outbreak. *Int J Environ Res Publ Health* 2020;17. <https://doi.org/10.3390/ijerph17093181>.
- [41] COVID-19 Significantly Impacts Health Services for Noncommunicable Diseases. 2020.

- [42] Ahmed SAKS, Ajisola M, Azeem K, et al. Impact of the societal response to COVID-19 on access to healthcare for non-COVID-19 health issues in slum communities of Bangladesh, Kenya, Nigeria and Pakistan: results of pre-COVID and COVID-19 lockdown stakeholder engagements. *BMJ Glob Health* 2020;5:e003042. <https://doi.org/10.1136/bmjgh-2020-003042>.
- [43] Mahmood S, Hasan K, Colder Carras M, et al. Global preparedness against COVID-19: we must leverage the power of digital health. *JMIR Public Heal Surveill* 2020;6:e18980. <https://doi.org/10.2196/18980>.
- [44] Hassan A, Arora RC, Lothar SA, et al. Ramping up the delivery of cardiac surgery during the COVID-19 pandemic: a guidance statement from the Canadian society of cardiac surgeons. *Can J Cardiol* 2020;36:1139–43. <https://doi.org/10.1016/j.cjca.2020.04.030>.
- [45] Randau TM, Jaenisch M, Haffer H, et al. Collateral effect of COVID-19 on orthopedic and trauma surgery. *PLoS One* 2020;15:1–17. <https://doi.org/10.1371/journal.pone.0238759>.
- [46] Montemurro P, Hedén P, Adams WP, et al. Effects of COVID-19 on plastic surgery practices and medi-spas in different countries. *Aesthet Surg J* 2020;40:NP453–6. <https://doi.org/10.1093/asj/sjaa104>.
- [47] Martinez D, Sarria GJ, Wakefield D, et al. COVID's impact on radiation oncology: a Latin American survey study. *Int J Radiat Oncol Biol Phys* 2020;108:374–8. <https://doi.org/10.1016/j.ijrobp.2020.06.058>.
- [48] Mascha EJ, Schober P, Schefold JC, et al. Staffing with disease-based epidemiologic indices may reduce shortage of intensive care unit staff during the COVID-19 pandemic. *Anesth Analg* 2020;131:24–30. <https://doi.org/10.1213/ANE.0000000000004849>.
- [49] Luedi MM, Doll D, Boggs SD, et al. Successful personalities in anesthesiology and acute care medicine: are we selecting, training, and supporting the best? *Anesth Analg* 2017;124:359–61. <https://doi.org/10.1213/ANE.0000000000001714>.