Lessons from the Comparison of Age Composition and Concomitant Mortality Profiles of COVID-19 Patients in Selected Developed and Developing Countries

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Abstract: In late December 2019, authorities in Wuhan, China, were informed of a new respiratory disease. They, in turn, notified the World Health Organization (WHO). On 30 January 2020, when there were about 10,000 cases of COVID-19 globally, the WHO cautioned of 'A public health emergency of international concern'. By the middle of September 2020, there were about 30 million cases globally, and the cumulative number of cases continued to rise, albeit at a lower rate. The pandemic's impacts are not homogenous. Some countries' have seen a few cases, while in others, the numbers have been significant. The pandemic's progression and mortality rates differ considerably. This paper looks at one reason for this variation, focusing on the age profiles of populations in selected countries. We draw out the public policy implications of this variation.

Keywords: COVID-19, age, mortality, morbidity, population, public health, policy

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Introduction

The SARS-CoV-2 pandemic has the largest impact on economic growth ever recorded. It has led to borders being closed, air travel suspended, massive unemployment and increasing poverty, and we are less than a year into the pandemic. This event is unlike anything the global community has experienced in modern times. Its effects go beyond the economic; they are political, social, and cultural, and although not yet fully appreciated, psychological. This global pandemic is the first in over 100 years, the last being the Spanish Influenza of 1918. The Spanish flu infected 500 million people resulting in 50 million deaths worldwide (Fottrell 2020a). Since the start of COVID-19, there have been some comparisons made to the previous pandemic. They have similar symptoms such as fever, coughing and body aches and spread through 'respiratory droplets' (Fottrell 2020a). However, one striking difference is the high rate of mortality among younger people. In the 1918 pandemic, 'mortality was high in people younger than 5 years old, 20-40 years old and 65 years old and older. The high mortality in healthy people, including those in the 20-40-year age group, was a unique feature of this pandemic' (Fottrell 2020a). COVID-19's mortality is highest for those 65 and older.

COVID-19 was first officially reported to the World Health Organization (WHO) on 31 December 2019 (Mackenzie & Smith 2020: 45). The first cases allegedly stemmed from a local 'wet' market in Wuhan, China where domestic and exotic animals - live and slaughtered - were sold as food (Lake 2020: 124). COVID-19 occurred when a retrovirus entered humans as a zoonotic disease. Zoonosis refers to a disease that crosses the species barrier from animal to human and then spreads from human to human (Cuthbert 2020). The human immunodeficiency virus that causes AIDS is the best-known example of this type of disease (Whiteside 2016). Other instances include Ebola, SARS-CoV and MERS-CoV (Cuthbert 2020).

The etymology is complicated. The International Committee on Taxonomy of Viruses (ICTV) is in charge of naming viruses (ICTV 2020). This virus is officially called 'severe acute respiratory syndrome coronavirus 2', abbreviated to SARS-CoV-2'. COVID-19 is the name for the disease, the '19' because it appeared in 2019 (Coronaviridae Study Group 2020: 536). The disease spreads rapidly between humans. The virus enters an uninfected person's respiratory tract as droplets or in aerosols. There is also a risk of

transmission from touching contaminated surfaces (Mackenzie & Smith 2020: 46). COVID-19 has a wide range of symptoms, primarily but not restricted to fever, cough, and difficulty breathing (Lake 2020: 124). Although China was first to report the outbreak to the WHO, evidence suggests there were isolated cases in Europe before this. Retroactive testing in France confirmed a case from December 2019 (Yeager 2020). In the U.K., a cluster of illnesses was reported from a choir in Bradford in early January 2020 (Wright 2020). The index case was the partner of a chorister, who returned from Wuhan in mid-December (Wright 2020).

COVID-19 spread rapidly, and the number of cases grew exponentially. On 30 January 2020, when there were about 10,000 cases, the WHO officially warned of, 'A public health emergency of international concern' (PHEIC) (WHO 2020a). The PHEIC is a formal declaration of 'an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease and to potentially require a coordinated international response' (WHO 2019). It is in reaction to a, 'serious, sudden, unusual or unexpected' situation, which 'carries implications for public health beyond the affected state's national border, and may require immediate international action' (WHO 2019). States have a legal duty to respond to a PHEIC. By July of 2020, there were COVID-19 cases in every nation. Countries responded by placing populations in lockdown, effectively confining people, other than essential workers, to their homes. International travel was and, at the time of this writing is, still banned or restricted, and internal movement remains heavily regulated. Canada and the U.S closed their shared border to non-essential travel in March; this closure was to remain in place until October 21st (The Canadian Press 2020). Many countries began to loosen up these regulations over the summer. Where there has been a resurgence of cases, countries are reapplying restrictions.

SARS-CoV-2's global case fatality rate, as of 21 September 2020, is 3.1 percent, which is significantly lower than its predecessors (Our World in Data 2020). It was 9.6 percent for SARS-CoV and 34.4 percent for MERS-CoV (Velavan & Meyer 2020: 279). What is certain is that the elderly (over 65) and those with comorbidities (underlying medical conditions) are the most vulnerable (Mackenzie & Smith 2020: 47). The main comorbidities associated with poor prognoses are diabetes, hypertension, respiratory diseases, cardiac issues, renal diseases and cancers (Guan *et al.* 2020: 11-12).

Several excellent websites track the pandemic; these include John Hopkins University, European Centre for Disease Control and Prevention and Worldometer. The one we used most consistently is Worldometer. As of 21 September 2020, the hardest-hit regions were the America's with 15,704,633 cases, followed by Asia with 9,420,535, and Europe with 4,524,724 (European CDC 2020). Africa, on the other hand, had relatively low numbers, with only 1,408,440 cases on 21 September 2020 (European CDC 2020). The number of cases continue to change rapidly as each month passes. In July 2020, Europe had 129,306 more cases than Asia. However, in September 2020, Asia had surpassed Europe by 4,895,811 cases (European CDC 2020). Africa has the least, but its case volume grew by 990,126 (European CDC 2020).

In this article, we review how differences in population age compositions between selected countries potentially contribute to the varying COVID-19 mortality rates. We conclude by discussing the policy implications of this, both for national governments and the global community.

Data and Vulnerability

Epidemiologists, virologists, public health specialists, policymakers, and politicians have been working together to understand the virus. Although scientific knowledge is increasing exponentially, there is still a great deal that remains unknown. The pandemic continues to spread, and the numbers continue to rise, albeit more slowly, as seen in the graph below.

A COVID-19 infection is included in a country's data if a laboratory test verifies it. Initially, the only diagnostic test available was an antigen test, which determined if an individual was positive for COVID-19. There was no antibody test to show who had been infected and recovered. These numbers are important to determine; of those infected, 30 percent are asymptomatic, but will be infectious for about 15 days, and 56 percent have mild to moderate symptoms but can infect others for up to three weeks (Pueyo 2020). Ten percent have severe symptoms and require health care (Pueyo 2020). The last four percent will be critically ill, and up to half of them may die (Pueyo 2020). The more seriously ill a person is, the longer they will be infectious (Pueyo 2020). COVID-19 is unique and a significant public health emergency, as people are asymptomatic for the first four to five days after infection, but can infect others.

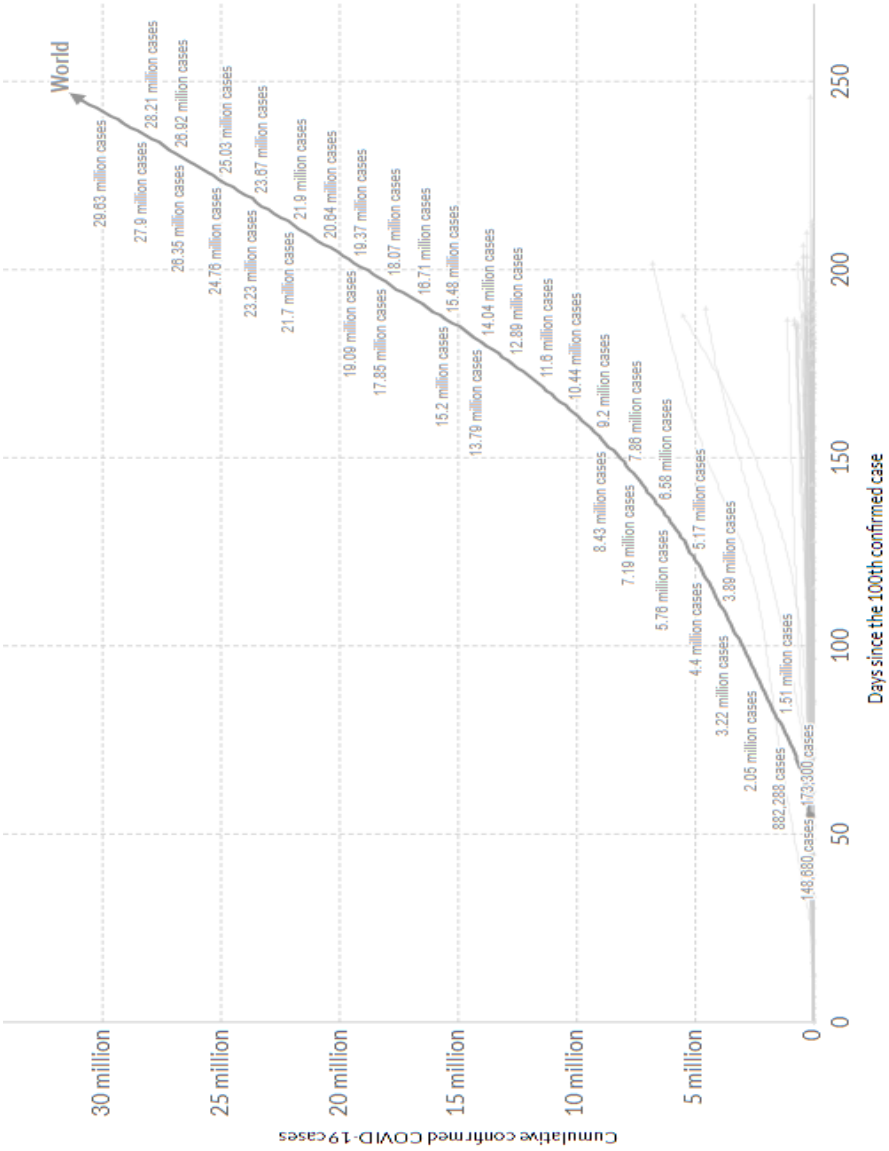

Figure 1: Our World in Data, Cumulative Confirmed COVID-19 Cases (2020)

Methodology, Concepts, and Literature

Initially, this paper set out to 'examine' the hypothesis that countries (or regions) with older populations may have more cases and higher morbidity and mortality. Overall, this seemed to be the case, but more data was needed to confirm it. It is now clear that those who are older, and have comorbidities are at greater risk of becoming ill and dying. In this article, as mentioned earlier, we review how differences in population age compositions between selected countries potentially contribute to the varying COVID-19 mortality rates. The implications of this analysis, both for national governments and the global community, are useful in considering public policy options. All the data collected came from publicly available and official data sources, academic journals, and books supplemented with press reports.

The key concepts are[1]:

- Infectiousness (as measured by the reproduction rate, R_0): This is the number of new infections one individual transmits. If each person infects more than one other, the epidemic will grow. If it falls below one, the epidemic will shrink.

- Infection fatality rate (IFR): How many infected people die? One must know how many are infected. If there are a large number of asymptomatic cases, it is not easy to establish the rate.

- Case detection rate: How many people with symptoms are detected?

- Case fatality rate (CFR): How many of the diseased died?

Arguably, the leading, reliable source of data is mortality (deaths). Most countries collect vital statistics, 'the number of births, deaths, or marriages which take place' (Collins Dictionaries 2020). Mortality data usually includes age, gender, and may give the cause of death.

[1] These terms are basic epidemiology and can be found text books and associated websites. For example, cf. Centers for Disease Control and Prevention. https://www.cdc.gov/biomonitoring/glossary.html

There is a correlation between the size of the older population and mortality. We did not look at the proportions housed in nursing facilities. However, there needs to be greater attention by scholars to their mortality rates and how their respective society treats them. In Italy, Sweden and Canada, many elderly are in these facilities; in Brazil and South Africa, numbers are smaller, and there are fewer nursing homes. They are exceedingly rare in Algeria and Ghana.

Age Composition

The age structure of a population determines many aspects of society, such as economic growth, labour force participation rates, demand for, and utilization of educational and healthcare services. Demographers divide populations into three broad age groups: Children and young adolescents (under 15 years old), the working-age population (15-64 years), and the elderly (65 years and older). The age dependency ratio (people below 15 and over 65 as a proportion of the 16 to 64 cohort) is important. The younger cohort requires investment in their upbringing and education, while the older segments of the population require support and care. The age structure of many populations has changed dramatically, and we selected countries to illustrate this. The choice, over five months ago, was based on the different population pyramids, which enabled us to 'visualize the demographic structure' (Ritchie & Roser 2019). The pyramids show the numbers in each age bracket by gender (Ritchie & Roser 2019). They are a snapshot of the demography and a view of the future as cohorts 'age up'.

Why does Age Composition Matter?

COVID-19 gives new significance to mortality and age. Morbidity (ill-health) and mortality increase with age, mostly due to non-communicable diseases (NCDs). Globally the top five causes of death are cardiovascular diseases, neoplasms (cancer), chronic respiratory disease, respiratory infections (including T.B.), and neurological disorders (Institute for Health Metrics and Evaluation 2017a). In high socio-development index countries (SDI)[2], they are

[2] Socio-Demographic Index measures a country's socio-demographic development by its income per capita, level of education and total fertility rate.

cardiovascular diseases, neoplasms (cancer), neurological disorders, and diabetes (Institute for Health Metrics and Evaluation 2017b). In low SDI countries, cardiovascular diseases, respiratory infections and T.B., maternal and neonatal disorders, enteric infections and chronic respiratory diseases constitute the primary causes of death (Institute for Health Metrics and Evaluation 2017c).

The global average life expectancy in 2019 was 72.6 years (Roser, Ortize-Ospina & Ritchie 2019). The life expectancy in the case study countries (Tables 1 and 2) ranges from 60.2 years in South Africa (United Nations, 'South Africa', 2019: 4), largely the result of the AIDS epidemic, to 85.4 in Italy (United Nations, 'Italy', 2019: 4). The countries first hit by COVID-19, China, South Korea, and Japan, were able to bring the epidemic under control (John Hopkins University 2020). Initially, the worst-hit European countries were Italy and Spain. By September 2020, the top four countries, with a million or more cases, were the USA, India, Brazil and Russia (Worldometer, 'Reported Cases', 2020).

Country Case Studies

We argue that understanding a country's age profile is vital, but not the only determinant of risk and impact. The responses of each country also create different epidemic curves. We chose to illustrate this with eight country case studies. In June 2020, we selected countries based on variances in their demographic structures and the COVID-19 data available. China was the epicentre and has an ageing population. The next three are high-income nations: Italy was the first European country to be affected and has a large demographic over the age of 65, Canada has a mixed demographic, and Sweden has an older population and took a different path to control COVID-19. Out of the developing and transitional countries, Brazil had the most out of control epidemic, although India now holds this unenviable status; South Africa has Africa's worst epidemic, while Algeria and Ghana provide different perspectives. Given the rapid evolution of this pandemic, we look at the COVID-19 epidemics in each country.

Table 1-Demographic Data for Country Case Studies

	China	Italy	Sweden	Canada
Total Population (2020 est)	1,439,324,000	60,578,000	10,099,000	37,742,000
% of people over 65 (2020 est.)	12%	23.3%	20.3%	18.1%
Human Development Index Ranking (2019)	85	29	8	13
Life Expectancy (M/F) (2020 est)	M: 74.5 F: 79.0	M: 81.0 F: 85.4	M: 80.8 F: 84.4	M: 80.2 F: 84.3
GDP per capita (2019)	$16,127	$36,141	$47,955	$43,602
Gender Development Index (GDI) (2018)	0.961	0.967	0.982	0.989
Gini Co-efficient (2017)	38.6	35.4	29.2	34
COVID-19 cases per 1 million as of September 21, 2020	59	4,955	8,725	3,810
Case Fatality Rates as of September 21, 2020	5.2%	12%	6.6%	6.4%

Table 2-Demographic Data for Country Case Studies

	Brazil	South Africa	Algeria	Ghana
Total Population (2020 est)	212,559,000	59,309,000	43,851,000	31,073,000
% of people over 65 (2020 est.)	9.6%	5.5%	6.7%	3.1%
Human Development Index Ranking (2019)	79	113	82	142
Life Expectancy (M/F) (2020 est)	M:71.9 F: 79.3	M: 60.2 F: 67.1	M:75.4 F: 77.8	M: 62.6 F: 64.7
GDP per capita (2019)	$14,068	$11,756	$13,639	$4,099
Gender Development Index (GDI) (2018)	0.995	0.984	0.865	0.912
Gini Co-efficient (2017)	53.3	63	27.6	43.5
COVID-19 cases per 1 million as of September 21, 2020	21,359	11,118	1,132	1,474
Case Fatality Rates as of September 21, 2020	3%	2.4%	3.4%	0.6%

China

China has the world's largest population. Its growth rate has been falling steadily since 2000 (United Nations, 'China', 2019: 4) and may become negative by 2027 (Myers, Wu & Fu 2020). The decline is due to consistent economic growth, rising costs of education and housing, and the one-child policy from 1979 to 2015 (Myers, Wu & Fu 2020). The population pyramid (Figure 2) reflects this. The under 15s comprise 17.7 percent of the population, and the over 65s account for 12 percent (United Nations, 'China', 2019: 4). The population is getting older in absolute and relative numbers. There is a gender imbalance due to the desire for male heirs, which led to selective abortions. As the population ages, the need for care increases.

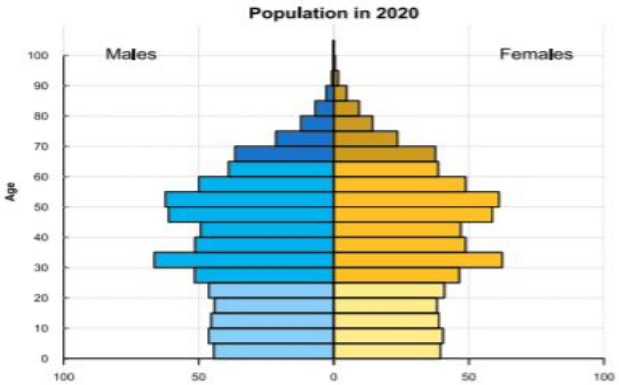

Figure 2[3]: U.N. Population Division, China (2019)

The first reported cases of COVID-19 were from Wuhan (Davidson 2020). The authorities reacted swiftly, and the disease has remained primarily confined to this area. The number of cases rose to 80,000 by early March 2020. By mid-September 2020, there have been 5,291 additional cases (Worldometer 'Reported Cases', 2020). Figure 3 shows the case fatality rates are significantly higher among the older populations. (Statista, 'China', 2020). The lesson from China is that it is possible to control the spread of COVID-19 and keep

[3] All the population pyramids, and subsequent demographic data in each case study is based off of U.N projections for 2020.

mortality low; the data shows fewer than 5,000 deaths (Worldometer, 'Reported Cases', 2020). As described in the New Yorker, China contained the virus through stringent control, which was willingly accepted by the citizens (Hessler 2020). The average case fatality rate in September 2020 was 5.2 percent (Our World in Data, 'Case Fatality Rate', 2020).

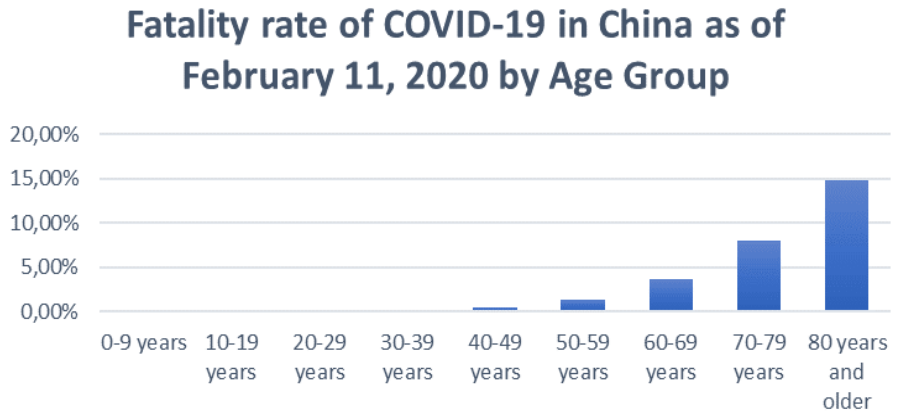

Figure 3: Statista, China (2020)

Italy

Italy has the world's second-oldest population (after Japan) (Scommegna 2019). The median age is 47.3 and will increase to 50.8 by 2030 (United Nation, 'Italy', 2019: 4). Negative growth and rising life expectancy are creating a demographic crisis (Johnson 2020). The population pyramid (Figure 4) reflects this ageing structure as only 13 percent are under 15, and over 65s account for 23.3 percent of the population (United Nations, 'Italy', 2019: 4).

The first recorded case of COVID-19 was on 20 February 2020, in Lombardy province (Godin 2020). Initially, Italy delayed its response, and the numbers exploded in March and April (Worldometer, 'Italy', 2020). 'If Italy's experience shows anything, it is that measures to isolate affected areas and limit the movement of the broader population need to be taken early, put in place with absolute clarity, then strictly enforced' (Horowitz, Bubola & Povoledo 2020). As Figure 5 shows, the elderly populations bore the brunt of the total mortality. The 60-69 age range accounts for 10 percent of the deaths,

increasing to 26 percent for the 70-79 age range and 41 percent for those aged 80-89 (Statista, 'Italy', 2020).

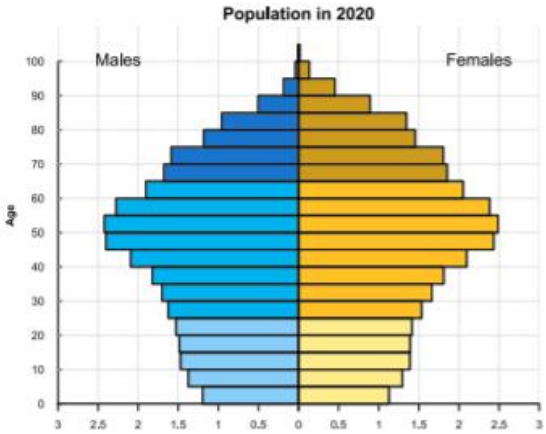

Figure 4: U.N. Population Division, Italy (2019)

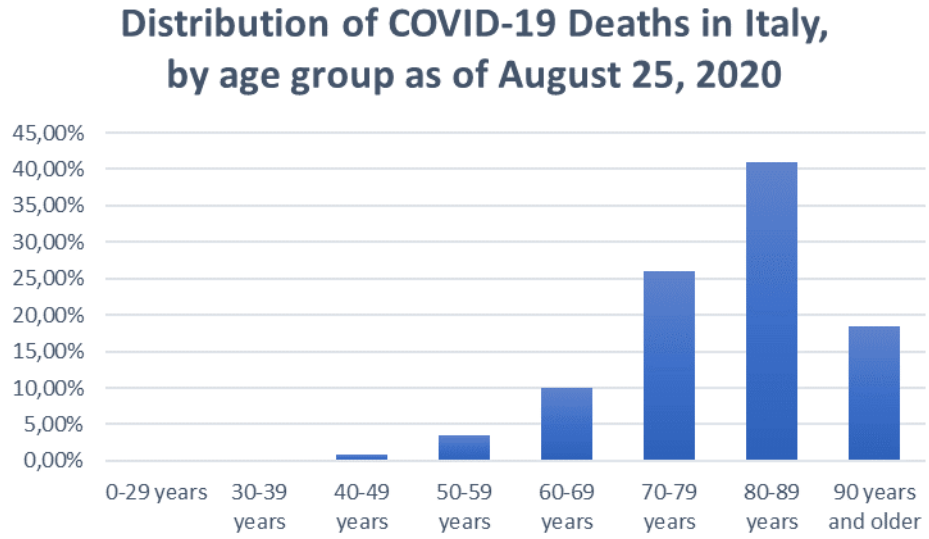

Figure 5: Statista, Italy (2020)

Italy's daily death toll declined from a high of 919 on March 27th to only three for a couple of days in July (Worldometer, 'Italy', 2020). The daily cases have increased since mid-August, but have not reached the same levels as seen in March (Worldometer, 'Italy', 2020). The overall case-fatality rate was high at 14.45 percent as of 2 July 2020, and decreased only slightly to 12 percent in September (Our World in Data, 'Case Fatality Rate', 2020). Up until mid-September there had been 299,506 total cases and 35,724 deaths (Worldometer, 'Italy', 2020). On May 16th, the government announced it would open its borders in early June to European tourists and lift the 14-day quarantine requirement (Euractive, 'Italy to reopen', 2020). After the country opened up again, the numbers initially remained low, and Italy appeared to be taking better control of its epidemic.

Sweden

Sweden has a looming demographic crisis, as the growth rate is below 1 percent (Macrotrends, 'Sweden', 2020). Figure 6 shows this disparity in growth as 17.6 percent of the population is under 15, while 20.3 percent is over 65 (United Nations, 'Sweden', 2019: 4).

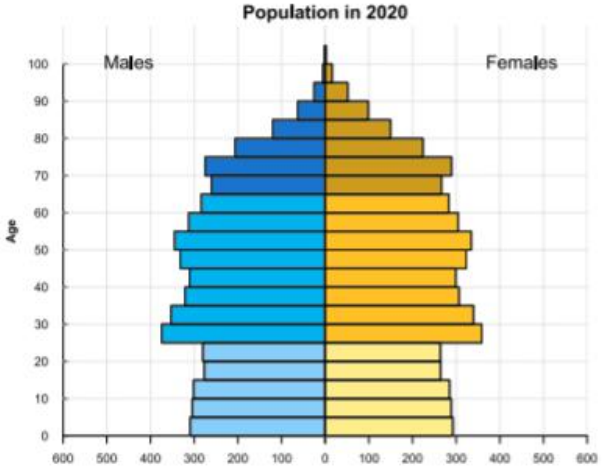

Figure 6: U.N. Population Division, Sweden (2019)

As Sweden's life expectancy (82.6) and median age (41.1) continues to increase (United Nations, 'Sweden', 2019: 4), Sweden will have to re-allocate resources to older populations and look to immigration to boost its growth.

Overall, Sweden is a progressive country revered for its approaches towards gender equality, innovation, healthcare and education. However, questions have arisen, both domestically and internationally, regarding their handling of the coronavirus. The first recorded infection was on January 24th, when a woman from Jönköping county tested positive after returning from Wuhan (Roden 2020). Instead of imposing strict lockdown protocols, Sweden decided to take a different approach and work towards herd immunity. This process occurs when a sufficient portion of the population develops immunity, halting its spread (Habib 2020: 1). Unfortunately, as of the end of May 2020, a study revealed that only 6.1 percent of the Swedish population had detectable antibodies (Rothschild 2020). This percentage is problematic as 'Epidemiologists estimate that at least 70% of the population attaining immunity is necessary to achieve herd immunity' (Fottrell 2020b). In September 2020, Sweden's Public Health Agency website only suggested staying an arm's length away, had no enforcement of social distancing nor a mandatory mask policy (Folkhälsomyndigheten 2020).

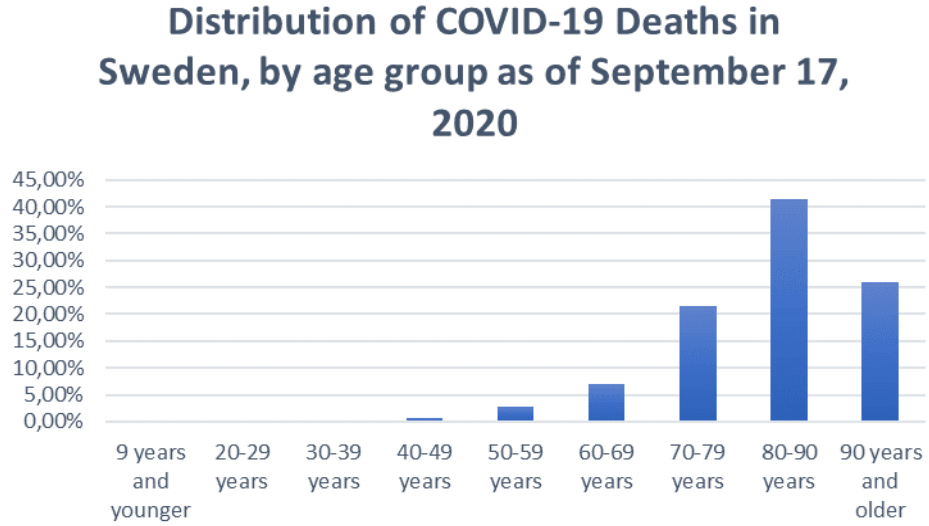

Figure 7: Statista, Sweden (2020)

Older segments of the population, aged 60 and up, accounted for 96 percent of the total deaths in Sweden since the start of the pandemic (Figure 7). Additionally, out of high SDI countries, Sweden had the smallest population, but the highest cases per million at 8,725, compared to 4,955 in Italy and 3,810 in Canada (Worldometer, 'Reported Cases', 2020).

As of 21 September 2020, Sweden had 88,237 cases compared to 23,323 in Denmark, 12,954 cases in Norway, and 9,046 cases in Finland (Worldometer, 'Reported Cases', 2020). Sweden's case fatality rate was 6.6 percent in September 2020 (Our World in Data, 'Case Fatality Rate', 2020). These neighbouring countries began to lift restrictions in May but remained closed to Swedish travellers (Milne 2020). Gradually over the summer, they have opened their borders to Sweden.

Canada

In 2019, Policy Options predicted Canada would soon be at a 'demographic pressure point' due to its declining workforce, which will impact its economy, standard of living and resources needed for social programs (Gill 2019). Under 15s account for 15.8 percent of the population, while over 65s make up 18.1 percent (United Nations, 'Canada', 2019: 4).

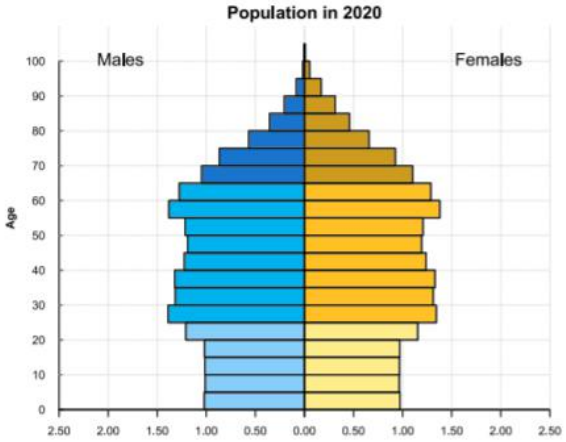

Figure 8: U.N. Population Division, Canada (2019)

The bulge shown in Figure 8 illustrates the median age of 41.1 (United Nations, 'Canada', 2019: 4). Increased immigration is a potential solution to this demographic dilemma (Gill 2020).

Coronavirus entered Canada on 25 January 2020, when a man in his 50's returned to Toronto from Wuhan, China (Staff - The Canadian Press 2020). He fell ill, was isolated at Toronto's Sunnybrook Hospital and two days later, the National Microbiology Laboratory confirmed he was positive for COVID-19 (Staff-The Canadian Press 2020). The virus began to spread rapidly in mid-March, April and into May, with cases declining in June (Worldometer, 'Canada', 2020). Canada had 144,076 cases and 9,219 deaths as of September 21 2020 (Worldometer, 'Canada', 2020). The number of daily cases fell from early May but increased slightly at the end of August (Worldometer, 'Canada', 2020).

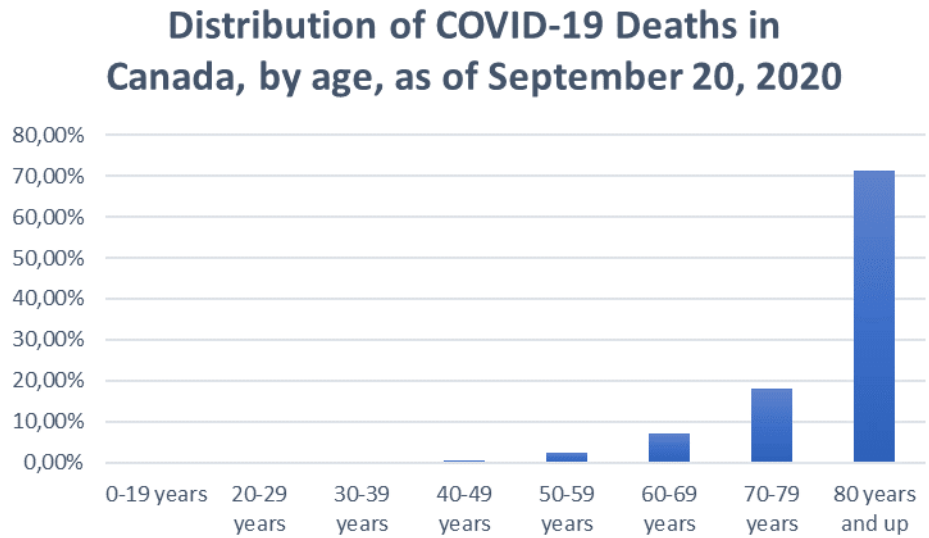

Figure 9: Government of Canada (2020)

Figure 9 shows the higher proportion of deaths in the older age brackets, with 97% of the deaths occurring in those aged 60 and over (Government of Canada 2020). This high fatality among older populations has mainly been in long-term care homes. The Canadian Institute for Health Information (CIHI) stated

that, as of May 25 2020, 80% of Canada's COVID deaths came from these homes (Grant 2020). The CIHI's report shows Ontario and Quebec (the hardest hit) failed to enact safeguards to protect elderly citizens (Grant 2020). Canada's average case fatality rate was 6.4 percent in September 2020 (Our World in Data, 'Case Fatality rate', 2020). Canada, like Italy, delayed its response and left older populations unprotected.

After exploring the age composition and COVID-19 impacts in China, as it was the alleged origin of the pandemic, the paper then looked at high SDI countries (Italy, Sweden, and Canada). We now turn to lower SDI countries with younger populations: Brazil, South Africa, Ghana and Algeria. What these case studies will show is that having a younger population can be advantageous to combat the pandemic, but only if combined with a vigorous response by the government to protect their citizens.

Brazil

Brazil accounts for half of South America's landmass and is the most populous country on the continent. The growth rate has been below 1 percent since 2009 (Macrotrends, 'Brazil', 2020). Despite the decrease in growth, the country has a relatively young population with a median age of 33.5 (United Nations, 'Brazil', 2019: 4).

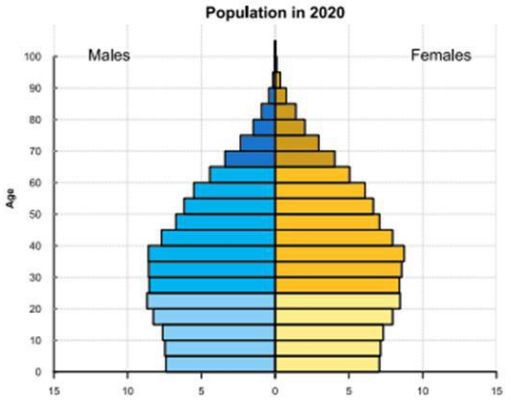

Figure 10: U.N. Population Division, Brazil (2019)

Figure 10 reflects this distribution 20.7 percent of the population is under 15, and 9.6 percent are over 65 (United Nations, 'Brazil', 2019: 4).

Brazil's first recorded coronavirus case was on February 26th. A 61-year-old resident from São Paulo tested positive after returning from Lombardy (Al Jazeera, 'Brazil Confirms', 2020). However, retroactive testing shows that the virus was present earlier. The Oswaldo Cruz Foundation reviewed cases of individuals with respiratory problems in late January and discovered a deceased patient was positive for COVID-19 (BBC News, 'Coronavirus: First Brazil Death', 2020).

Incidence was low from February to April but increased exponentially from May with daily cases in the tens of thousands (Worldometer, 'Brazil', 2020). On 19 June 2020, Brazil became the second country (after the U.S.) to pass one million cases (Fonseca & Stargardter 2020). It held this unenviable status until August when India's cases surged.

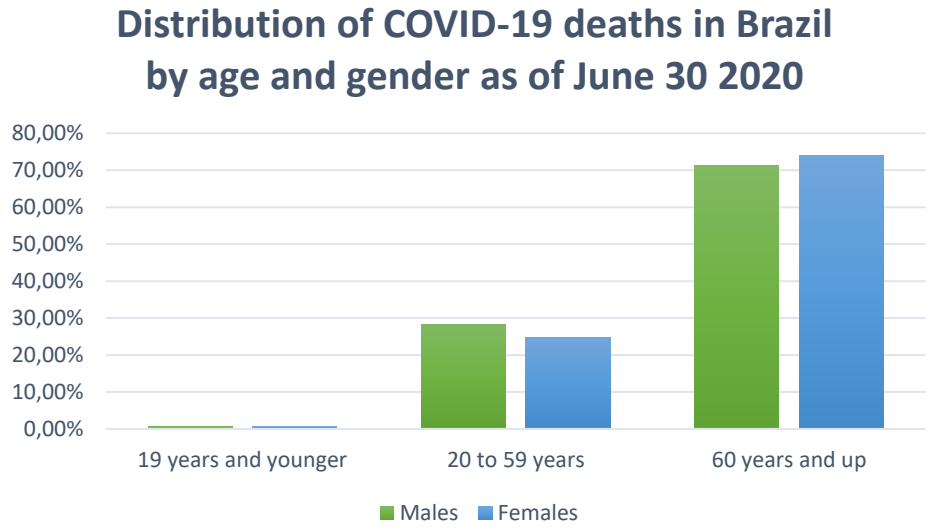

Figure 11: Baptista & Queiroz (2020: 6)

The international community has criticized President Bolsonaro for his responses to the crisis. Nicknamed the 'Tropical Trump', Bolsonaro has denounced social distancing as a 'job-killing measure more dangerous than the virus itself' (Fonseca & Stargardter 2020)'. Bolsonaro, like, Trump has also

pushed chloroquine and hydroxychloroquine as possible treatments (Fonseca & Stargardter 2020). Since April 2020, Brazil had no permanent health minister in place, as two left their posts due to tensions with the President (Fonseca & Stargardter 2020). Instead, Army General Eduardo Pazuello (who has no medical experience) ran the department in the interim (Reverdosa, Wenzel & Pedroso 2020). In September 2020, President Bolsonaro swore him in as the official health minister (Savarese & Biller 2020).

The Brazilian government manipulated the COVID-19 numbers on their national website (Fonseca 2020). As a result, any data presented is questionable and demographic data regarding cases and deaths is nearly impossible to find. However, we located one paper on mortality rates up to 30 June 2020, see Figure 11 (Baptista and Queiroz 2020: 1). The highest proportion of deaths are Brazilians over 60 (Baptista and Queiroz 2020: 6).

As of 21 September 2020, according to Worldometer, Brazil had 4,547,150 cases and 136,997 deaths (2020). Its case fatality rate was also 3 percent at that time (Our World in Data, 'Case Fatality Rate', 2020). Brazil is an example where, despite having a younger population, lack of leadership, mitigation measures and reliable data have crippled its ability to contain the virus. The consequences of inaction are especially visible in the number of cases per million, as Brazil had 21,359, the highest of our selected countries (Worldometer, 'Reported Cases', 2020). These numbers demonstrate that age composition is important, but not the only factor to consider when analyzing the pandemic.

South Africa

The South African situation is different from much of Africa; the population growth rate declined substantially and has been under 2 percent since 1996 (The World Bank 2019). The median age is currently 27.6, with 28.8 percent of the population under the age of 15 and over 65s accounting for only 5.5 percent (United Nations, 'South Africa', 2019: 4). The smaller percentage of older individuals is due to South Africa's low life expectancy (60.2 for men and 67.1 for women) (United Nations, 'South Africa', 2019: 4). What makes South Africa's demography unique is the mortality from the AIDS epidemic, especially before the arrival of comprehensive treatment in 2004. Effectively there was a 'lost' generation with women bearing a greater burden than men. UNAIDS's 2018 data showed that 7.7 million people (in a population of just

under 60 million) live with HIV. The prevalence rate among those aged 15 - 49 is 20.4 percent (UNAIDS 2018). In 2018, 71,000 people died from AIDS, but 240,000 people became infected with HIV (UNAIDS).

AIDS is still the primary cause of death; in 2017, it accounted for 28.5 percent of all deaths in the country (Institute for Health Metrics and Evaluation, 2017d). For women aged 15 to 49, the percentage of deaths from AIDS is an astounding 67.19 percent (Institute for Health Metrics and Evaluation 2017e). The older cohort remains small, and there are imbalances between men and women (Figure 12). Research into the links between HIV and COVID-19 is underway. The consensus is that HIV positive people taking Anti-Retroviral Therapy are not at greater risk. However, as the mortality data thus far has shown, those with immuno-compromised systems are high risk.

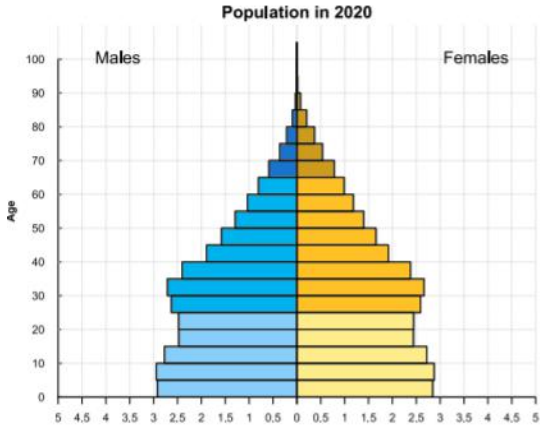

Figure 12: U.N. Population Division, South Africa (2019)

The National Institute for Communicable Diseases announced South Africa's first coronavirus case on 5 March 2020 (Minister of Health, Dr. Mkhize 2020). The first death occurred on 27 March 2020, prompting the government to implement an initial 3-week nation-wide lockdown with strict military and police enforcement (Delay, Ntshangase & Magome 2020). During the lockdown, the daily cases remained low. South Africa started to ease its restrictions on May 1st when the number of cases stood at 5,951 (Worldometer, 'South Africa', 2020). Shortly after, the daily cases grew exponentially,

reaching numbers over 10,000 for most of July (Worldometer, 'South Africa', 2020). By 21 September 2020, there had been 661,211 cases and 15,953 deaths (Worldometer, 'South Africa', 2020) and an average case fatality of 2.4 % (Our World in Data, 'Case Fatality rate', 2020). Both the daily number of cases and deaths have decreased since mid-August but have been rising again.

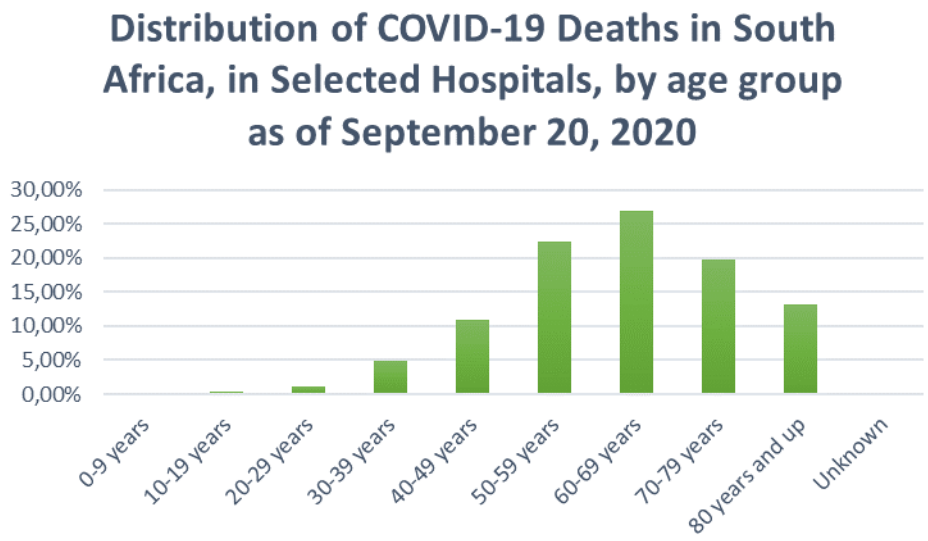

Figure 13: National Institute for Communicable Diseases (2020:1)

The National Institute for Communicable Diseases (NICD) conducts COVID-19 tracking in select hospitals (Figure 13). 269 Public and 244 Private hospitals are reporting admissions, interventions, discharges, and age and gender data for the deceased to the NICD (NICD 2020: 2). By 20 September 2020, NICD had provided age and gender data for 78% of South Africa's total deaths. The graph shows a significant proportion of deaths (10.98 percent), start in the age cohort of 40 to 49 and increase to 49 percent for those aged 50-69. The latter is not surprising as South Africa's average life expectancy is in the 60s; there are not many older people thanks to AIDS.

The next two countries show quite a different age profile.

Algeria

Algeria's current growth rate is 1.85 percent, increasing its population by 800,000 each year (World Population Review 2020). Unlike the previous country case studies, Algeria has a high total fertility rate, with around three children per woman (World Population Review 2020). The country has a relatively young population with a median age of 28.5 (United Nations, 'Algeria', 2019: 4). As per Figure 14, 30.8 percent are under 15, and only 6.7 percent over 65 (United Nations, 'Algeria', 2019: 4).

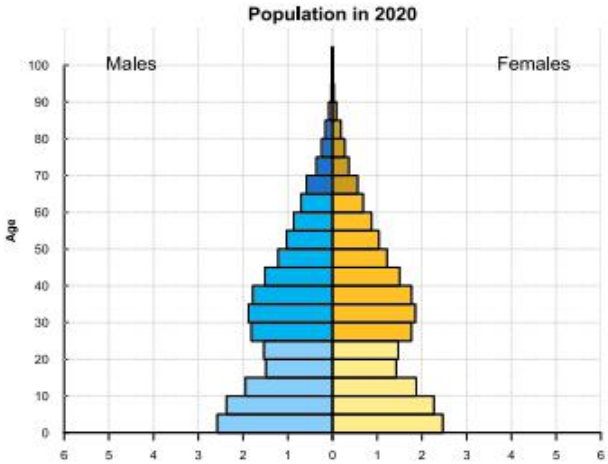

Figure 14: U.N. Population Division, Algeria (2019)

The first recorded COVID-19 case was on 17 February 2020, when an Italian citizen tested positive (At Editor 2020). From late March onwards, cases were reported daily, with the largest number being 675, occurring on July 24th (Worldometer, 'Algeria', 2020). These numbers are minimal compared to the non-African countries listed in this article. As of 21 September 2020, Algeria reported 49,826 COVID-19 cases and just 1,672 deaths (Worldometer, 'Algeria', 2020).

There is limited data regarding the demographic breakdowns of COVID-19 cases in Algeria; however, researchers Saad Eddine Boutebal and Azzeddine Madani provide a glimpse into this with their May 2020 article.

They found demographic data for 459 deaths, see Figure 15 (Boutebal & Madani 2020: 3).

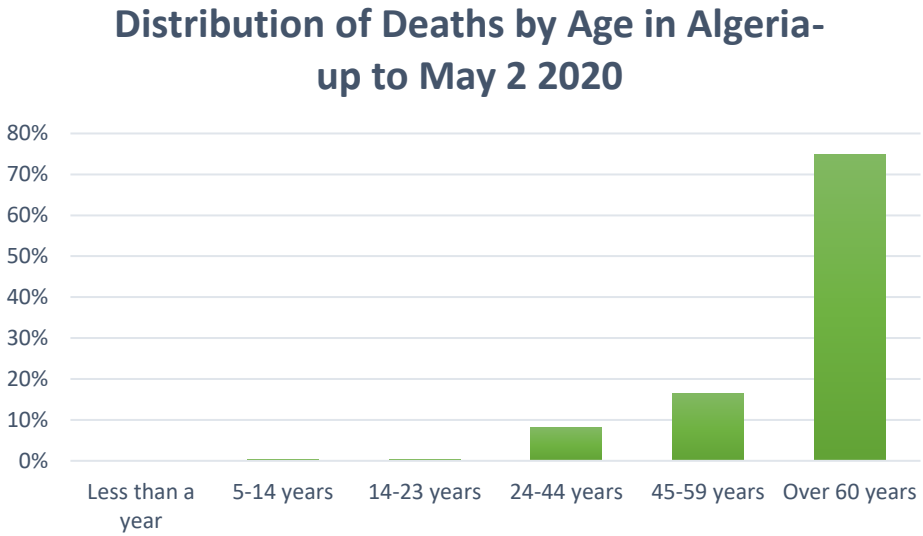

Figure 15: Boutebal and Madani (2020: 3)

The number of deaths in the lower age brackets is minimal, while the older bracket accounts for 74.94 percent of the deaths (Boutebal & Madani 2020: 3).

As of 9 September 2020, the World Health Organization in the African Region (WHO) noted that Algeria accounts for 6.7% of the total deaths in Africa (3). However, 'complete data on age and gender distribution is only available for 1.1%' in the region (WHO African Region 2020: 3), thus making a more thorough analysis challenging.

The data available suggests that younger age demographics help lessen the disease burden; however, adequate measures need to be put into place to protect their older populations. Algeria has 30 labs for testing 'with an average capacity of 2,500 tests across these labs' (WHO African Region 2020: 9).

Ghana

Since the 1990s, Ghana's population growth rate has stayed under 3 percent (Macrotrends, 'Ghana', 2020). The decline was due to policy changes,

including increased investment in education and growing incomes for small farmers (Kaps 2020). Regardless of these changes, Ghana has the youngest population structure of our case studies, with a median age of 21.5 (United Nations, 'Ghana', 2019: 4). Figure 16 reflects this: 37.1 percent of the population is under the age of 15, and only 3.1 percent is over 65 (United Nations, 'Ghana', 2019: 4).

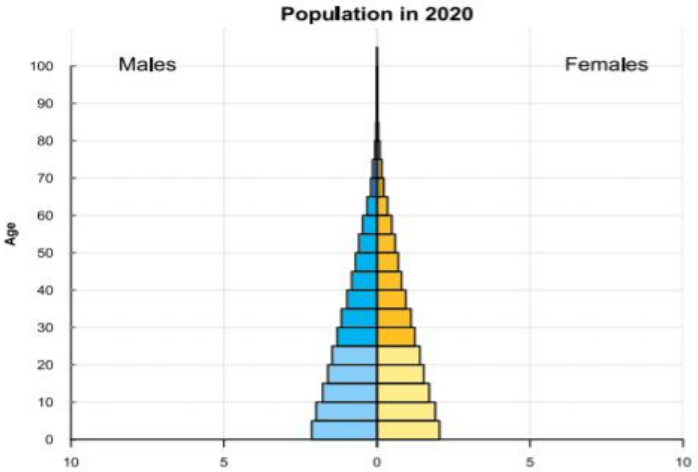

Figure 16: U.N. Population Division, Ghana (2019)

On 12 March 2020, the Ministry of Health released a statement advising Ghanaians of the country's first two COVID-19 cases, infected in Norway and Turkey, respectively (Ministry of Health, Kwaku Agyeman-Manu 2020). On March 28th, Ghana became one of the first African countries to declare a lockdown (Quakyi 2020). President Nana Akufo-Addo stated, 'We know how to bring the economy back to life. What we do not know is how to bring people back to life' (Quakyi 2020). The world praised Ghana's response; however, on April 19th, the lockdown ended, and cases began to increase (Quakyi 2020).

As of 21 September 2020, Worldometer reports Ghana has 46,004 reported cases and only 297 deaths (about 1.3 % of the total deaths in Africa) (WHO African Region 2020: 3). The average case fatality rate was 0.6 percent (Our World in Data, 'Case Fatality Rate', 2020). Ghana presents an interesting case, as its fatality rate remains low. Some argue that Ghana's poor health

infrastructure and testing capabilities may be contributing to its lower numbers; however, we postulate their young society is one of the factors keeping the pandemic at bay.

Conclusion

The data presented shows that countries with younger populations have fewer severe COVID-19 cases and deaths. There are caveats to this paper. The first is that COVID-19 is a new disease, only identified at the beginning of 2020. This uncertainty means we are not sure how the epidemiology will unfold. Will Africa continue to see fewer cases? The Brazilian epidemic is severe; could it be a harbinger for Africa, due to its similar population distribution? Second, as is well documented, most infections are asymptomatic or very mild and are probably not recorded. This lack of data may mean COVID-19 has spread, largely unnoticed, through countries with younger populations. However, this is a protective factor because there will be fewer reported cases, and not as many older adults seeking care. COVID-19 may not add significantly to the disease burden.

China, the first nation to see COVID-19, brought it under control and contained it through draconian, authoritarian measures. China is hyperaware of the dangers of a resurgence and continues to monitor the situation. The cost has been tremendous, and the economy will go from rapid growth to potential contraction. The experience of SARS in 2002 provided a template for China, which meant that despite the severity of the disease, they have been able to contain it. This rapid containment also occurred in the few cases outside Wuhan city and Hubei Province (Hessler 2020).

The Italian case saw the nation's health sector being overwhelmed. The epidemic rose from 234 daily cases on February 28th to a peak of 6,557 by March 21^{st,} and numbers remained high at about 3000 cases per day until early May (Worldometer, 'Italy', 2020). The Italian epidemic was worsened by comorbidities: smoking, high rates of chronic obstructive pulmonary disease, and ischemic heart disease. Additionally, Italy was the first country to see an uncontrolled epidemic, so it had no experience (Boccia, Ricciardi & Ioannidis 2020: 927-928). China, Italy and Canada illustrate the vulnerability of the elderly and the need to provide care for them.

Canada is a wealthy country with a well-developed public health system and a small population spread out over a large area. These factors,

combined with the SARS experience, means COVID-19 is under control, and the impact is not as devastating as in other high-income countries. However, Canada provides an example of how specific vulnerable groups can be overlooked and devastated, especially the elderly, in institutional care.

Sweden's epidemic is one to watch, especially as we begin to count the cost of the lockdowns on economies and society more broadly. If there is a less severe economic impact and the country does not see a second wave, then the 'herd immunity' approach will have been a gamble that, while it cost some lives, may have been worth it.

Brazil has a similar population distribution to South Africa and many other emerging middle-income countriesyet for a time had the second second-worst epidemic in the world. It is an outlier because of the lack of leadership, indeed the willful denial of the problem.

The ultimate experience of such denial was the HIV epidemic in South Africa, and the consequence of this was disastrous and long term (Whiteside 2016). South Africa has an additional burden of AIDS, and T.B. and observers and health care providers are uncertain about the implications (del Amo *et al.* 2020). Following the easing of the lockdown, the disease is spreading rapidly. The epidemic in South Africa, Algeria, and Ghana are some months behind other countries. Algeria has a youthful population, and Ghana has the youngest population of our cases. We postulate they may avoid a serious COVID-19 epidemic, and in the case of South Africa, the number of new cases had fallen dramatically. The age structure seems to be the key determinants of both the severity and spread of COVID-19. When combined with levels of poverty, inequality and standard of leadership, we may be able to account for all the variation between countries.

We did not address two issues in this paper, one is speculative, and the other is certain and evolving. It would be interesting to compare mortality rates across countries by looking at the treatment of older people when they can no longer live on their own. The global experience shows that long-term care homes had disproportionately higher morbidity and mortality rates, suggesting that when the care for the elderly is in extended families, their prospects could be better. However, this may not be the case if there was a higher rate of exposure. This analysis is beyond the scope of this paper.

The public policies that were put in place as the pandemic grew were draconian and highly reactive. Perhaps the most stringent were in China. 'Neighbourhood committees … enforced the rules, and in many places, they

limited households to sending one individual outside every two to three days to buy necessities' (Hessler 2020). Other interventions included the mandatory wearing of face masks, restrictions on where and how citizens could travel, and the need to keep a distance from others.

Many of the interventions put in place worldwide may seem extreme; however, they helped slow the spread of the virus, giving the health services time to prepare for influxes in patients needing extensive interventions.

However, economic, social, psychological, and cultural costs have been enormous. This year has been a year of deaths, not just the estimated, but the death of everyday life, the death of ambitions and plans, and forms of social interaction, to name a few. It is hardly surprising that we are collectively in mourning.

The inevitable consequence of COVID-19 is the contraction of economies. High SDI countries can afford to support their populations for a time. The situation in low SDI countries is bleak. They will have to deal with increased poverty, hunger and other diseases for many years. It will be imperative to research the impacts of these short-term public policies.

The case studies above demonstrate that epidemic preparedness should consider the age structure and chronic diseases of the population served by each healthcare system. Overall, even when there is a vaccine, effective public policies will play a pivotal role in containing this virus.

Declaration: This research article originated as a preliminary think piece for the Balsillie Paper series at https://www.balsillieschool.ca/covid-19-age-and-mortality-implications-for-public-policy/. Since its publication on 2 June 2020, the pandemic and response have evolved, as reflected in this updated and expanded article.

References

AT Editor 2020. Algerian Health Minister Confirms First COVID-19 Case. *Africa Times.* Available at: https://africatimes.com/2020/02/25/algerian-health-minister-confirms-first-covid-19-case/ (Accessed on 24 June 2020.)

Boccia, S., W. Ricciardi & J.P.A. Ioannidis 2020. What Other Countries Can Learn from Italy During the COVID-19 Pandemic. *JAMA Internal Medicine* 180, 7: 927-928. Available at:

doi:10.1001/jamainternmed.2020.1447 (Accessed on 26 June 2020.) https://doi.org/10.1001/jamainternmed.2020.1447
PMid:32259190

Brazil Confirms First Coronavirus Case in Latin America 2020. Al Jazeera. Available at: https://www.aljazeera.com/news/2020/02/brazil-confirms-coronavirus-case-latin-america-200226144612605.html (Accessed on 27 June 2020.)

Collins Dictionaries 2020. *Definition of 'Vital Statistics'.* Available at: https://www.collinsdictionary.com/dictionary/english/vital-statistics. (Accessed on 20 May 2020)

Coronaviridae Study Group of the International Committee on Taxonomy of Viruses 2020. *The Species Severe Acute Respiratory Syndrome-related Coronavirus: Classifying 2019-nCoV and Naming it SARS-CoV-2. Nature Microbiology* 5: 536-544. Available at: https://www.nature.com/articles/s41564-020-0695-z#citeas (Accessed on 2 June 2020.) https://doi.org/10.1038/s41564-020-0695-z
PMid:32123347 PMCid:PMC7095448

Coronavirus: First Brazil Death 'Earlier than Thought' 2020. BBC News. Available at: https://www.bbc.com/news/world-latin-america-52638352 (Accessed on 27 June 2020.)

Cuthbert, L. 2020. *How do Infections like Coronavirus Jump from Animals to People?* National Geographic. Available at: https://www.nationalgeographic.com/science/health-and-human-body/human-diseases/how-do-animals-pass-dangerous-zoonotic-diseases-to-humans-zoonoses-coronavirus/#close (Accessed on 1 June 2020.)

Davidson, H. 2020. *First Covid-19 Case Happened in November, China Government Records Show - Report. The Guardian.* Available at: https://www.theguardian.com/world/2020/mar/13/first-covid-19-case-happened-in-november-china-government-records-show-report (Available on 4 June 2020.)

Del Amo, J., R. Polo, S. Moreno, A. Díaz, E. Martínez, J. Arribas, I. Jarrín, M. Hernán & The Spanish HIV/COVID-19 Collaboration 2020. Incidence and Severity of COVID-19 in HIV-Positive Persons Receiving Antiretroviral Therapy: A Cohort Study Original Research. Annals of Internal Medicine: n. pag. Web. Available at: https://www.acpjournals.org/doi/10.7326/M20-3689

(Accessed on 26 June 2020.) https://doi.org/10.7326/M20-3689 PMid:32589451 PMCid:PMC7394316

Delay, J., N. Ntshangase & M. Magome 2020. *'Go home!' South Africa has 1st Death as Lockdown Begins.* AP News. Available at: https://apnews.com/bfc7ea8a58cdea3e79d485da37fe085c?utm_source=Media+Review+for+March+27%2C+2020&utm_campaign=Media+Review+for+March+27%2C+2020&utm_medium=email (Accessed on 26 June 2020.)

European Centre for Disease Prevention and Control 2020. *COVID-19 Situation Update Worldwide, as of 21 September 2020*. ECDC. Available at: https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases. (Accessed on 21 September 2020.)

Folkhälsomyndigheten (Swedish Public Health Agency) 2020. Question and Answers about COVID-19 (Coronavirus). Available at: https://www.folkhalsomyndigheten.se/smittskydd-beredskap/utbrott/aktuella-utbrott/covid-19/fragor-och-svar/ (Accessed on 18 September 2020.)

Fonseca, P. 2020. COVID-19: Anger as Brazil Removes Months of National Data from View, Posts Wildly Differing Death Tallies. *National Post.* Available at: https://nationalpost.com/news/world/covid-19-anger-as-brazil-removes-months-of-national-data-from-view-posts-wildly-differing-death-tallies (Accessed on 27 June 2020.)

Fonseca, P. & G. Stargardter 2020. Brazil Becomes just Second Country to Pass 1 Million Coronavirus Cases. *Global News.* Available at: https://globalnews.ca/news/7087758/brazil-1-million-coronavirus-cases/ (Accessed on 27 June 2020.)

Fottrell, Q. 2020a. *Here's one 'Remarkable' Difference between COVID-19 and the 1918 Spanish Flu.* Market Watch. Available at: https://www.marketwatch.com/story/heres-one-remarkable-difference-between-covid-19-and-the-1918-spanish-flu-2020-07-07 (Accessed on 22 September 2020.)

Fottrell, Q. 2020b. *Sweden Embraced Herd Immunity, while the U.K. Abandoned the Idea – So Why do They Both have high COVID-19 Fatality Rates?* Market Watch. Available at: https://www.marketwatch.com/story/uk-abandoned-herd-immunity-while-sweden-embraced-it-how-possible-is-it-to-achieve-herd-immunity-without-a-vaccine-2020-08-26

(Accessed on 19 September 2020.)

Gill, J. 2019. *Canada Needs a Lot More People, and Soon.* Policy Options. Available at: https://policyoptions.irpp.org/magazines/november-2019/canada-needs-a-lot-more-people-and-soon/ (Accessed on 27 June 2020.)

Godin, M. 2020. Why is Italy's Coronavirus Outbreak So Bad? *Time*. Available at: https://time.com/5799586/italy-coronavirus-outbreak/ (Accessed on 4 June 2020.)

Grant, K. 2020. 81% of COVID-19 Deaths in Canada were in Long-term Care – Nearly Double OECD Average. *The Global and Mail*. Available at: https://www.theglobeandmail.com/canada/article-new-data-show-canada-ranks-among-worlds-worst-for-ltc-deaths/ (Accessed on 2 July 2020.)

Guan, W., W. Liang, Y. Zhao, H. Liang, Z. Chen, Y. Li, X. Liu, R. Chen, C. Tang, T. Wang, C. Ou, L. Li, P. Chen, L. Sang, W. Wang, J. Li, C. Li, L. Ou, B. Cheng, S. Xiong, Z. Ni, J. Xiang, Y. Hu, L. Liu, H. Shan, C. Lei, Y. Peng, L. Wei, Y. Liu, Y. Hu, P. Peng, J. Wang, J. Liu, Z. Chen, G. Li, Z. Zheng, S. Qiu, J. Luo, C. Ye, S. Zhu, L. Cheng, F. Ye, S. Li, J. Zheng, N. Zhang, N. Zhong & J. He on behalf of China Medical Treatment Expert Group for Covid-19 2020. Comorbidity and its Impact on 1590 Patients with COVID-19 in China: A Nationwide Analysis. *European Respiratory Journal* 55, 5:1-14. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7098485/ (Accessed on 1 June 2020.) https://doi.org/10.1183/13993003.00547-2020 PMid:32217650 PMCid:PMC7098485

Habib, H. 2020. Has Sweden's Controversial COVID-19 Strategy been Successful? *BMJ Feature* 1 - 2. Available at: https://doi.org/10.1136/bmj.m2376 (Accessed on 25 June 2020.) PMid:32532807

Hessler, P. 2020. *How China Controlled the Virus: Teaching and Learning in Sichuan during the Pandemic. The New Yorker*. Available at: https://www.newyorker.com/magazine/2020/08/17/how-china-controlled-the-coronavirus. (Accessed on 10 September 2020.)

Horowitz, J., Em. Bubola & E. Povoledo 2020. *Italy, Pandemic's New Epicenter, Has Lessons for the World.* The New York Times. Available at: https://www.nytimes.com/2020/03/21/world/europe/italy-coronavirus-center-lessons.html. (Accessed 23 May 2020.)

ICTV 2020. *International Committee on Taxonomy of Viruses.* ICTV. Available at: https://talk.ictvonline.org/ (Accessed on 23 May 2020.)

Institute for Health Metrics and Evaluation 2017a. *GDB Compare – Global – Both Sexes, All ages, 2017, Deaths.* Global Disease Burden. Available at: https://vizhub.healthdata.org/gbd-compare/ (Accessed on 28 June 2020.)

Institute for Health Metrics and Evaluation 2017b. *GDB Compare – High SDI –Both Sexes, All Ages, 2017, Deaths.* Global Disease Burden. Available at: https://vizhub.healthdata.org/gbd-compare/ (Accessed on 28 June 2020.)

Institute for Health Metrics and Evaluation 2017c. *GDB Compare – Low SDI –Both Sexes, All Ages, 2017, Deaths.* Global Disease Burden. Available at: https://vizhub.healthdata.org/gbd-compare/ (Accessed on 28 June 2020.)

Institute for Health Metrics and Evaluation 2017d. *GDB Compare – South Africa – Both Sexes, All Ages, 2017, Deaths.* Global Disease Burden. Available at: https://vizhub.healthdata.org/gbd-compare/ (Accessed on 28 June 2020.)

Institute for Health Metrics and Evaluation 2017e. *GDB Compare – South Africa-Females, 15-49 years, 2017, Deaths.* Global Disease Burden. Available at: https://vizhub.healthdata.org/gbd-compare/. (Accessed on 28 June 2020.)

Italy to Reopen Borders for EU Tourists in Early June 2020. Euractiv. Available at: https://www.euractiv.com/section/coronavirus/news/italy-to-reopen-borders-for-eu-tourists-in-early-june/ (Accessed on 23 May 2020.)

Johns Hopkins University & Medicine Coronavirus Resource Center 2020. *COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE).* John Hopkins University (JHU). Available at: https://coronavirus.jhu.edu/map.html. (Accessed on 2 July 2020.)

Johnson, M. 2020. *Italy's Collapsing Birth Rate Rings Demographic Alarm Bells. Financial Times.* Available at: https://www.ft.com/content/a9d1fe0c-2306-11ea-92da-f0c92e957a96. (Accessed on 1 June 2020.)

Kaps, A. 2020. *More and More, Older and Older.* Development and Cooperation. Available at: https://www.dandc.eu/en/article/both-ageing-societies-declining-populations-and-growing-youthful-ones-face-serious. (Accessed on 15 June 2020.)

Lake, M.A. 2020. What we Know So Far: COVID-19 Current Clinical Knowledge and Research. *Clinical Medicine (London, England)* 20, 2: 124–127. Available at: https://www-ncbi-nlm-nih-gov.proxy.lib.uwaterloo.ca/pmc/articles/PMC7081812/ (Accessed on 26 May 2020). https://doi.org/10.7861/clinmed.2019-coron PMid:32139372 PMCid:PMC7081812

Mackenzie, J.S. & D.W. Smith 2020. *COVID-19: A Novel Zoonotic Disease Caused by a Coronavirus from China: What we Know and What we Don't. Microbiology Australia* 41, 1: 45 - 50. Available at: ncbi.nlm.nih.gov/pmc/articles/PMC7086482/ (Accessed on 1 June 2020.) https://doi.org/10.1071/MA20013 PMid:32226946 PMCid:PMC7086482

Macrotrends 2020. *Brazil Population Growth Rate 1950-2020.* Available at: https://www.macrotrends.net/countries/BRA/brazil/population-growth-rate. (Accessed on 24 June 2020.)

Macrotrends 2020. *Ghana Population Growth Rate 1950-2020*. Available at: https://www.macrotrends.net/countries/GHA/ghana/population-growth-rate. (Accessed on 24 May 2020.)

Macrotrends 2020. *Italy Population Growth Rate 1950-2020.* Available at: https://www.macrotrends.net/countries/ITA/italy/population-growth-rate. (Accessed on 16 May 2020.)

Macrotrends 2020. *Sweden Population Growth Rate 1950-2020.* Available at: https://www.macrotrends.net/countries/SWE/sweden/population-growth-rate. (Accessed on 25 June 2020.)

Milne, R. 2020. *Coronavirus: Sweden starts to debate its public health experience*. FT. Available at: https://www.ft.com/content/7ecd5ded-9b90-4052-b849-0e153f701e1f. (Accessed on 25 June 2020.)

Minister of Health, Dr. Z. Mkhize 2020. *First Case of COVID-19 Coronavirus Reported in SA*. National Institute for Communicable Diseases. Available at: https://www.nicd.ac.za/first-case-of-covid-19-coronavirus-reported-in-sa/. (Accessed on 28 June 2020.)

Minister of Health, Kwaku Agyeman-Manu 2020. *For Immediate Release: Ghana Confirms Two Cases of COVID-19*. Ministry of Health. Available at: https://www.ghanahealthservice.org/covid19/downloads/covid_19_first_confirmed_GH.pdf (Accessed on 15 June 2020.)

Myers, S.L, J. Wu & C. Fu 2020. China's Looming Crisis: A Shrinking Population. *The New York Times.* Available at: https://www.nytimes.com/interactive/2019/01/17/world/asia/china-population-crisis.html (Accessed on 6 June 2020.)

Our World in Data 2020. *Case Fatality Rate of Ongoing COVID-19 Pandemic*. Coronavirus Pandemic Data Explorer. Available at: https://ourworldindata.org/grapher/coronavirus-cfr (Accessed on 21 September 2020.)

Pueyo, T. 2020. *Coronavirus: The Hammer and the Dance.* Medium. Available at: https://medium.com/@tomaspueyo/coronavirus-the-hammer-and-the-dance-be9337092b56 (Accessed on 21 June 2020.)

Quakyi, N.K. 2020. Ghana's much Praised COVID-19 Strategy has Gone Awry. Here is Why. *The Conversation.* Available at: https://theconversation.com/ghanas-much-praised-covid-19-strategy-has-gone-awry-here-is-why-143217 (Accessed on 21 September 2020.)

Reverdosa, M., F. Wenzel & R. Pedroso 2020. *Amid Pandemic, Brazil's Health Ministry still has an Interim Boss with no Medical Experience*. CNN World. Available at: https://www.cnn.com/2020/08/18/americas/brazil-coronavirus-interim-health-minister-intl/index.html. (Accessed on 18 September 2020.)

Ritchie, H. & M. Roser 2019. *Age Structure*. Our World in Data. Available at: https://ourworldindata.org/age-structure. (Accessed on 1 June 2020.)

Roden, L. 2020. *First Case of Coronavirus in Sweden Confirmed*. Sverigeradio. Available at: https://sverigesradio.se/sida/artikel.aspx?programid=2054&artikel=7398979. (Accessed on 25 June 2020.)

Rothschild, N. 2020. *New Study: 6.1 Percent of Swedes had Developed COVID-19 Antibodies by Late May*. Sverigesradio. Available at: https://sverigesradio.se/artikel/7498860 (Accessed on June 25 2020.)

Roser, M., E. Ortize-Ospina & H. Ritchie 2019. *Life Expectancy*. Our World in Data. Available at: https://ourworldindata.org/life-expectancy (Accessed on 25 May 2020.)

Scommegna, P. 2019. *Which Country has the Oldest Population? It Depends on How You Define 'Old.'* Population Reference Bureau. Available at: https://www.prb.org/which-country-has-the-oldest-population/ (Accessed on 15 September 2020.)

Staff-The Canadian Press 2020. Coronavirus: Here's a Timeline of COVID-19 Cases in Canada. *Global News.* Available at: https://globalnews.ca/news/6627505/coronavirus-covid-canada-timeline/. (Accessed 26 June 2020.)

The Canadian Press 2020. *Canada - U.S. Border Closure Extended to Oct. 21*. CTV News. Available at: https://www.ctvnews.ca/politics/canada-u-s-border-closure-extended-to-oct-21-1.5110565 (Accessed on 18 September 2020.)

The World Bank. *Population Growth (Annual%) - South Africa.* Available at: https://data.worldbank.org/indicator/SP.POP.GROW?locations=ZA&display=graph (Accessed on 18 May 2020.)

UNAIDS. *South Africa.* Available at: https://www.unaids.org/en/regionscountries/countries/southafrica (Accessed on 26 April 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Algeria.* World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Algeria.pdf. (Accessed on 24 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Brazil.* World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Brazil.pdf. (Accessed on 24 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Canada.* World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Canada.pdf. (Accessed 25 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Dynamics 2019.*China.* Population Division- World Population Prospects 2019: 1 - 6 Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/China.pdf (Accessed on 25 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Ghana.* World Population Prospects 2019, Volume II: Demographic Profiles (2019): 1 - 6. Available at:

https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Ghana.pdf (Accessed on 25 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Italy*. World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Italy.pdf (Accessed on 4 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *South Africa*. World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/South%20Africa.pdf (Accessed on 4 June 2020.)

United Nations, Department of Economic and Social Affairs, Population Division 2019. *Sweden*. World Population Prospects 2019, Volume II: Demographic Profiles: 1 - 6. Available at: https://population.un.org/wpp/Graphs/1_Demographic%20Profiles/Sweden.pdf (Accessed on 10 June 2020).

Velavan, T.P & C.G. Meyer 2020. The COVID-19 Epidemic. *Tropical Medicine and International Health* 24,3: 278-280. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7169770/ (Accessed on 24 May 2020.) https://doi.org/10.1111/tmi.13383 PMid:32052514 PMCid:PMC7169770

Whiteside, A. 2016. *HIV and AIDS: A Very Short Introduction, Second Edition.* Oxford: Oxford University Press. https://doi.org/10.1093/actrade/9780198727491.001.0001

WHO 2019. *What is a Public Health Emergency of International Concern?* WHO Newsroom. Available at: https://www.who.int/news-room/q-a-detail/what-are-the-international-health-regulations-and-emergency-committees (Accessed on 24 May 2020.)

WHO 2020a. *Statement on the Second Meeting of the International Health Regulations (2005) Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV).* WHO Newsroom. Available at: https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov) (Accessed on 1 June 2020.)

WHO African Region 2020b. *COVID-19: Situation Update for the WHO African Region 09 September 2020.* World Health Organization: 1-11. Available at: https://reliefweb.int/report/south-africa/covid-19-situation-update-who-african-region-external-situation-report-28-09 then click on Situation Report. (Accessed on 20 September 2020.)

Worldometer 2020. *Algeria*. Available at: https://www.worldometers.info/coronavirus/country/algeria/ (Accessed on 21 September 2020.)

Worldometer 2020. *Brazil*. Available at: https://www.worldometers.info/coronavirus/country/brazil/ (Accessed on 21 September 2020.)

Worldometer 2020. *Canada.* Available at: https://www.worldometers.info/coronavirus/country/canada/ (Accessed on 21 September 2020.)

Worldometer 2020. *Ghana.* Available at: https://www.worldometers.info/coronavirus/country/ghana/ (Accessed on 21 September 2020.)

Worldometer 2020. *Italy*. Available at: https://www.worldometers.info/coronavirus/country/italy/ (Accessed on 21 September 2020.)

Worldometer 2020. *Reported Cases and Deaths by Country, Territory, or Conveyance*. Available at: https://www.worldometers.info/coronavirus/ (Accessed on 21 September 2020.)

Worldometer 2020. South Africa. Available at: https://www.worldometers.info/coronavirus/country/south-africa/ (Accessed on 29 June 2020.)

World Population Review 2020. *Algeria.* Available at: https://worldpopulationreview.com/countries/algeria-population/ (Accessed on 24 June 2020.)

Wright, J. 2020. *Coronavirus Doctor's Diary: The Strange Case of the Choir that Coughed in January*. BBC News. Available at: https://www.bbc.co.uk/news/health-52589449 (Accessed on 12 May 2020.)

Yeager, A. 2020. *Doctors Date First COVID-19 Case in France to Late December*. The Scientist. Available at: https://www.the-scientist.com/news-opinion/doctors-date-first-covid-19-case-in-france-to-late-december-67510 (Accessed on 15 May 2020.)

References for Tables 1 and 2

*** Total Population, % of people over 65 and Life expectancy are pulled from the same page from each country report. The central database to retrieve data is the following:**

United Nations, Department of Economic and Social Affairs, Population Dynamics. 2019. *Graphs/ Profiles.* Population Division – World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/900 (Accessed on 25 June 2020.)

*** HDI and GDP statistics from the same source:**

United Nations Development Programme 2019. *2019 Human Development Index Ranking.* Human Development Reports. Available at: http://hdr.undp.org/en/content/2019-human-development-index-ranking. (Accessed 25 June 2020.)

United Nations Development Programme 2018. *Gender Development Index.* Human Development Reports. Available at: http://hdr.undp.org/en/indicators/137906 (Accessed on 25 June 2020.)

United Nations Development Programme 2017. *Income Inequality, Gini Coefficient.* Human Development Reports. Available at: http://hdr.undp.org/en/indicators/67106 (Accessed on 25 June 2020.)

Worldometer 2020. *Reported Cases and Deaths by Country, Territory, or Conveyance*. Available at: https://www.worldometers.info/coronavirus/ (Accessed on 21 June 2020.)

Our World in Data. 2020. *Case Fatality Rate of Ongoing COVID-19 Pandemic.* Coronavirus Pandemic Data Explorer. Available at: https://ourworldindata.org/grapher/coronavirus-cfr (Accessed on 21 September 2020.)

References for Figures 1-16

Figure 1

Our World in Data 2020. *Cumulative Confirmed COVID-19 Cases.* Available: https://ourworldindata.org/coronavirus-data-explorer?zoomToSelection=true&time=2020-03-

14..latest&country=~OWID_WRL&region=World&casesMetric=true&interval=total&aligned=true&hideControls=true&smoothing=0&pickerMetric=location&pickerSort=asc
(Accessed on 19 September 2020.)

Figure 2

United Nations, Population Division 2019. *China.* World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/156 (Accessed on 4 June 2020.)

Figure 3

Statista. 2020. *Fatality Rate of Novel Coronavirus COVID-19 in China as of 11 February 2020, by Age Group.* Available at: https://www.statista.com/statistics/1099662/china-wuhan-coronavirus-covid-19-fatality-rate-by-age-group/ (Accessed on 21 September 2020.)

Demographic data on the breakdown of COVID mortalities were hard to find for China, which is why this figure shows fatality rates over the distribution of deaths.

Figure 4

United Nations, Population Division 2019. *Italy.* World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/380 (Accessed on 25 June 2020.)

Figure 5

Statista 2020. *Distribution of Coronavirus (COVID-19) Deaths in Italy as of 25 August 2020, by Age Group.* Available at: https://www.statista.com/statistics/1106367/coronavirus-deaths-distribution-by-age-group-italy/ (Accessed on 21 September 2020.)

Figure 6

United Nations, Population Division 2019. *Sweden.* World Population Prospects 2019. Available at:

https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/752 (Accessed on 25 June 2020.)

Figure 7

Statista. 2020. *Number of Coronavirus (COVID-19) Deaths in Sweden in 2020, by Age Groups (as of 17 September 2020).* Available at: https://www.statista.com/statistics/1107913/number-of-coronavirus-deaths-in-sweden-by-age-groups/ (Accessed on 21 September 2020.)

Figure 8

United Nations, Population Division. 2019. *Canada*. World Population Prospects. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/124. (Accessed on 25 June 2020.)

Figure 9

Government of Canada. 2020. *Coronavirus Disease 2019 (COVID-19): Epidemiology Update. Age and Gender Distribution of COVID-19 Cases Deceased in Canada as of 21 September 2020.* Available at: https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html (Accessed on 21 September 2020.)

Figure 10

United Nations, Population Division. 2019. *Brazil*. World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/124. (Accessed on 24 June 2020.)

Figure 11

Baptista, E.A & B.L. Queiroz. 2020. Regional Covid-19 Mortality in Brazil by Age. *SocArXiv* 1-12. Available at: https://osf.io/preprints/socarxiv/ujstp/ (Accessed on 20 September 2020.)

Figure 12

United Nations, Population Division 2019. *South Africa.* World Population Prospects 2019. Available at:

https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/710. (Accessed on 26 June 2020.)

Figure 13

National Institute for Communicable Diseases 2020. *NICD COVID-19 Surveillance in Selected Hospitals*: 1-2. Available at: https://www.nicd.ac.za/wp-content/uploads/2020/09/NICD-COVID-19-Daily-Sentinel-Hospital-Surveillance-report-National-20200920.pdf. (Accessed on 21 September 2020.)

Figure 14

United Nations, Population Division. 2019. *Algeria.* World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/12. (Accessed on 27 June 2020.)

Figure 15

Boutebal, S.E. & A. Madani 2020. Gravity of the (COVID-19) Pandemic in the First Deconfinement Phase in Algeria. *SSRN* 1-6. Available at: http://dx.doi.org/10.2139/ssrn.3598663 (Accessed on 24 June 2020.)

Figure 16

United Nations, Population Division. 2019. *Ghana.* World Population Prospects 2019. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/288 (Accessed on 24 June 2020.)

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