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December 19, 2020 – January 8, 2021

Early COVID-19 vaccination rollout top performers

Main message

In November and December 2020, the first countries around the world embarked on a mass vaccination effort against COVID-19 to curb-—and ideally end—the ongoing pandemic that has killed or caused illness in millions of people and disrupted the lives and livelihoods of billions. Relative to the global population, the vaccine supply is currently severely limited. People who live in high-income countries have the most access. In countries that have initiated vaccination programs, millions of doses have been delivered, but getting those doses into people's arms has presented unique challenges that are often specific to particular settings and contexts. Despite an overall lag during the first month of vaccine rollout, there are places where advance planning, reliance on existing partnerships, strong public health and health care infrastructure, and the participation of highly visible public figures have all played a role in relative success. As the vaccination effort continues and accelerates, countries need to combat vaccine hesitancy, manage supply chains reliably, optimize vaccination data and tracking systems, and improve population- and individual-level access to safe and effective vaccination against COVID-19. Lessons may be learned from the countries and U.S. states that have most efficiently rolled out vaccination.

Situation in the United States

The U.S. Food and Drug Administration (FDA) granted its first emergency use authorization for a COVID-19 vaccine on Dec. 11, 2020 and the first vaccines were administered soon after. As of Jan. 11, 2021, about 9 million people in the U.S. have received the first dose of either of the two COVID-19 vaccines currently authorized for emergency use. Although the rate of vaccination is increasing rapidly in some areas, as of Jan. 11, just over a third of the almost 26 million vaccine doses that have been distributed to states and territories since mid-December have been administered. While the U.S. Centers for Disease Control and Prevention (CDC) is maintaining an interactive and updated vaccination data tracker, individual states and jurisdictions are also registering each dose administered, and many are reporting on the progress of their vaccination campaigns publicly as part of vaccination data dashboards (e.g., Ohio, Michigan, Vermont).

Operation Warp Speed, a partnership between the federal government and private companies that has been, in part, supporting the development, manufacture and distribution of COVID-19 vaccines, had hoped to have 20 million vaccines administered by the end of 2020. Per news accounts, the actual number delivered and administered fell far short to less than 14 million doses delivered and 3 million administered. Although Operation Warp Speed was able to deliver 14 million doses across the country by the end of 2020, there were problems with the rollout and actual injection of shots into recipients' arms. Reduced hours from holidays, lack of funding to support state and local vaccination infrastructure, and overstretched health departments already responding to COVID-19 have been cited as some reasons rollout was slow in U.S. jurisdictions.

States were allotted vaccine doses based mainly on the size of their population. Some states have been able to achieve higher vaccination rates—many of them states with the lowest population density. In these states, including Montana, North Dakota, South Dakota, Alaska and New Mexico, most health care personnel who are currently prioritized are likely to be clustered near a few urban centers with larger medical complexes, thereby reducing distribution and logistical challenges. In addition to West Virginia, which is currently the top performer for vaccine initiation (number of people receiving the first dose per capita), by Jan. 8, 2021, Alaska, D.C., Maine, Vermont, North Dakota and South Dakota each had a cumulative vaccination rate of more than 2,750 first doses administered per 100,000 people. By Jan. 11, almost half of U.S. states had reached this milestone. The incoming administration has announced plans to vaccinate at least 100 million people in the first 100 days of the new administration in 2021—an average of 1 million people per day. So far, days with the highest single-day vaccination totals have only reached about half of that number.

Top-performer case study: West Virginia

West Virginia kicked off its COVID-19 vaccination campaign on Dec. 14, 2020, days before most other states. Its National Guard—a planning and implementation partner whose leadership had been part of the state's vaccine task force—was involved from the start. During the first week of vaccine rollout in the U.S., West Virginia was administering more than 90% of the vaccine doses that were being delivered to the state—a higher proportion than any other state. It had also successfully administered a first dose of vaccine to a large proportion of its long-term care facility (LTCF) residents and staff before a national campaign targeting the same priority group had even begun. Based on these early successes, the state is adapting its vaccination plan to reach as many priority populations as possible while vaccine supply remains below overall demand. As of Jan. 8, West Virginia had successfully administered first-dose vaccinations at all of its LTCFs and had started to administer second doses, which should be given three to four weeks after the initial dose according to the vaccine manufacturers and the FDA. States are taking advantage of a public-private partnership called the Pharmacy Partnership for Long-Term Care Program for COVID-19 Vaccination to distribute, deliver, administer, track and report vaccinations in its LTCFs. However, since Walgreens and CVS pharmacies, the partners included in the program, are less common in the state, West Virginia partnered with 250 local independent pharmacies and used existing facility-pharmacy relationships to further vaccination in its LTCFs. This move has been cited as one of the reasons for West Virginia's early success.

Although the overall vaccine rollout is rapidly evolving and gaining momentum in many parts of the country, as of Jan. 8, West Virginia continues to have the highest first-dose vaccination rate, at more than 4,000 per 100,000 people—more than double most of its neighboring states and four times higher than the lowest performing states: Georgia, Mississippi and Alabama. The state has administered nearly 60% of the vaccine doses that it has received and has expanded its vaccination campaign to include teachers and school staff as well as people over 80 years old. On its state COVID-19 vaccination website, West Virginia posts frequent updates about current and forthcoming eligibility, locations for upcoming vaccination clinics and answers to frequently asked questions about many aspects of the vaccine for the general public.

The state's governor has been actively involved in the COVID-19 vaccine rollout process, making frequent media appearances and delivering public announcements about the state's progress, program expansions and new campaigns for priority groups. He was one of the first public officials to receive the vaccine and did so in order to help instill confidence about its safety.

Paving a path to smoother and faster vaccination

While some states struggle with sticking to phases and further stratifying subgroups of highest risk within priority populations (e.g. by prioritizing the oldest people or those with underlying medical conditions within essential workers), some experts are encouraging more states to take a less literal approach to the phased rollout and administer the vaccines as efficiently as possible. The nation has been withholding 50% or more of its available vaccine supply in order to allow for completion of the second dose of vaccination that is proven to achieve full efficacy for both vaccines that are currently authorized for use. This is despite plans that are in place for much wider vaccine availability in the coming months. On Jan. 8, President-elect Joe Biden's team announced that the new administration would move away from this conservative stockpiling approach and use the available supply to administer more first doses, while relying on future supply to cover demand for second doses. This does not address the issue that the best performing states are currently only administering about 60% of their allotted doses. Other strategies for how to improve and accelerate vaccination efforts in the U.S. include improving funding for implementation at state and local health departments, opening more "megasites" where thousands of vaccines can be administered daily, improving the reliability of vaccine supply at the state and local level, and bolstering ongoing public health messaging with large-scale advertising campaigns.

Sampling of State Vaccination Metrics (as of Jan. 11, 2020)

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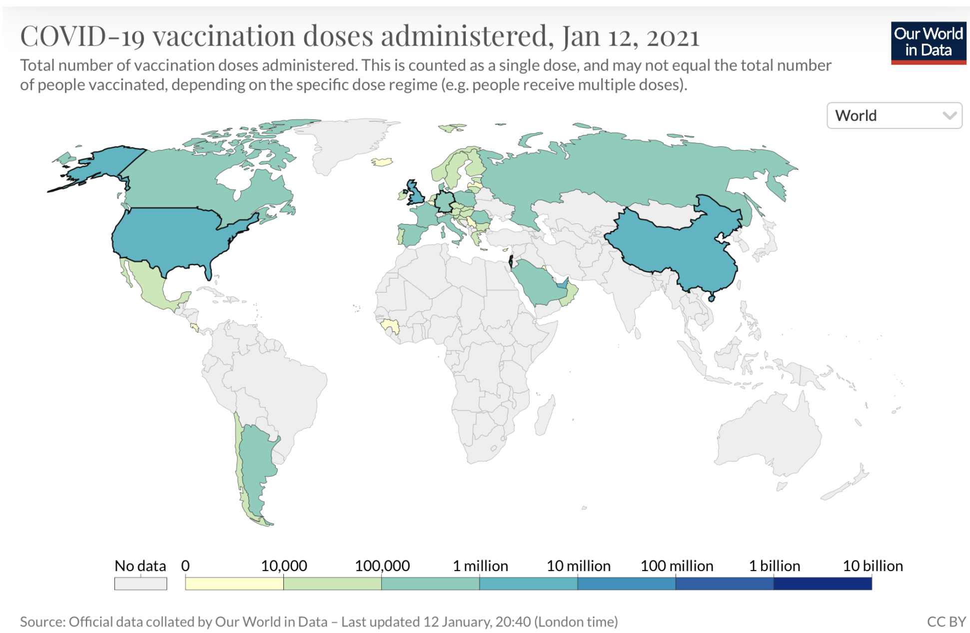
	Total doses delivered (per 100,000 people)	Total first doses administered (per 100,000 people)	Estimate percent of delivered doses administered*
California	2,833,400 (7,171)	782,638 (1,981)	28%
Georgia	770,625 (7,258)	142,909 (1,346)	19%
Maine	108,775 (8,092)	54,594 (4,088)	50%
North Dakota	53,525 (7,024)	38,868 (5,100)	72%
Texas	1,942,300 (6,699)	852,015 (2,938)	44%
Michigan	765,900 (7,669)	222,379 (2,227)	29%
Washington, D.C.	60,775 (8,611)	29,228 (4,141)	48%
West Virginia	160,975 (8,982)	96,337 (5,376)	60%

** Actual percent of doses delivered slightly higher given some second doses being administered by Jan. 11. Source: **CDC COVID Data Tracker***

Global situation

There are many factors that can increase the speed and reach of a nationwide COVID-19 vaccination campaign. Some are specific to the COVID-19 pandemic and vaccine rollout, including vaccination campaign design and vaccine availability, while others are complex, longer-standing, broader factors such as health care system infrastructure, level of trust in the government and population size. Some COVID-19 pandemic-specific factors are directly tied to broader factors; for example, vaccine availability correlates with country wealth. It can be difficult to pinpoint any single factor to explain vaccine campaign outcomes, and it can be challenging to determine causal relationships between factors and outcomes. What follows is a description of the approaches to vaccine rollout taken by two countries with relatively high per capita rates of vaccination, with a focus on factors that may contribute to performance. It is important to note that the vast majority of low- and middle-income countries do not yet know exactly when vaccines will reach them; it may be several years until large proportions of those countries' populations are vaccinated. The below map shows which countries have rolled out COVID-19 vaccination and the total vaccines administered.

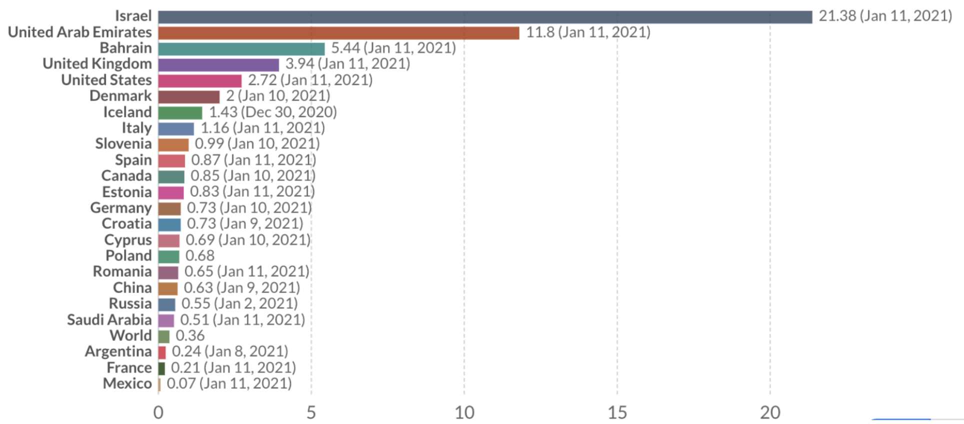
COVID-19 vaccination doses administered, Jan 12, 2021



Source ***Our World in Data***

The chart below shows the per capita rate of vaccination in a number of countries. It is worth noting that the top performers in terms of total vaccines administered are not necessarily the same countries that are top performers in terms of population coverage. For example, as of January 11, Israel reported administering ~1.8 million vaccines and ~21% of its population, while the United States had reported administering ~9 million vaccines and ~2.7% of its population

COVID-19 vaccinations administered per 100 people as of January 11



Source ***Our World in Data***

Top-performer case study: Israel

Soon after the U.S. FDA granted emergency use authorization for the Pfizer vaccine, Israel's Ministry of Health approved the Pfizer vaccine and launched its vaccination campaign on Dec.19, 2020. On Jan. 4, the Ministry of Health approved the Moderna vaccine and the first shipment of doses recently arrived in Israel.

Israel's vaccine rollout is planned in two waves. In the initial wave, health care workers and first responders are eligible to receive the vaccine, followed by those older than 60. In the subsequent wave, those with specified underlying comorbidities will be vaccinated first, followed by high-exposure groups (such as teachers, social workers and prisoners) and then by the general population. So far, Israel has had a sufficient vaccine supply to vaccinate the intended groups at a high rate. However, vaccines may soon become a scarce resource in Israel because of the rate at which vaccines are being administered. If that occurs, the rate of vaccination may slow until more vaccine doses are delivered to the country. In November 2020, Israel reportedly signed a deal with Pfizer to secure 8 million COVID-19 vaccine doses, which is almost enough to provide two doses to half of Israel's population of 8.8 million. The number of Pfizer vaccine doses received and the expected schedule of delivery of more doses has not been disclosed. Verified information on the number or schedule of Moderna doses delivered or promised is not publicly available.

Before the vaccination campaign began, 20% of Israelis responding to an August survey said they would not take an approved vaccine. This is on par with hesitancy rates reported from other countries. In a November survey, a minority of Israelis said they would agree to be inoculated in the first wave. There have since been extensive public health messaging campaigns on COVID-19 vaccination. Some efforts have focused on minority populations that current data or historical trends suggest may be more likely to decline vaccination, including Arab Israelis and members of the ultra-Orthodox Jewish community. Messaging has been targeted to these communities, and trusted religious and community leaders have come forward to publicly encourage vaccination. The prime minister of Israel was vaccinated on Dec. 19, upon initiation of the vaccine campaign.

In Israel, most adults are registered with one of four health maintenance organizations. As a result, health records for the entire adult population are digitized and centralized. These records are being used to register individuals to be vaccinated. Some vaccinations, in particular for the health care workforce, are administered in centralized hospitals and vaccination centers. Other vaccine shipments are being subdivided into smaller bundles and transported to outlying delivery centers within pizza-sized insulated boxes designed to keep vaccines at recommended ultra-cold temperatures. Repackaging vaccine solution shipments may facilitate the use of vaccine vans as well as 150 new vaccination administration complexes that are more accessible to people who may not be able to easily access centralized locations. This is in contrast with the U.S., where subdivision of the hundreds of vaccine solution vials held in Pfizer thermal shipping containers is not recommended; smaller containers are expected from Pfizer in coming months.

Top-performer case study: Bahrain

On Dec. 4, Bahrain became the second country in the world (after the United Kingdom) to approve the Pfizer vaccine. On Dec. 13, Bahrain's Ministry of Health approved the COVID-19 vaccine BBIBP-CorV, which was developed by the Beijing Institute of Biological Products and put into trials by the Chinese company Sinopharm. Bahrain's National Health Regulatory Authority stated that BBIBP-CorV Phase III clinical trials demonstrated 86% vaccine efficacy, however, trial results are not publicly available. Trials were conducted in several countries including Bahrain and the United Arab Emirates, which approved the vaccine several days before Bahrain. Reportedly, in November, Bahrain began inoculation with BBIBP-CorV of front-line workers as well as some senior officials, prior to completion of Phase III trials. Bahrain formally launched its vaccination campaign on Dec. 17; the King of Bahrain was vaccinated prior to campaign launch.

All citizens and residents of Bahrain are eligible to receive a vaccine. Registration for a vaccination appointment can be completed online or via a smartphone application. Reportedly, when scheduling vaccinations, users can choose between the Pfizer or Sinopharm vaccine and choose the location at which they prefer to be vaccinated. Verified information on the number of vaccination locations, the vaccine distribution plan or the number of doses of each vaccine that have been purchased by or received by Bahrain are not publicly available.

Lessons learned about potential bottlenecks to vaccine rollout

It is not possible to pinpoint a single obstacle to implementation of a COVID-19 vaccination program. This review of vaccine rollout in countries and U.S. states that have vaccinated relatively high proportions of their populations has highlighted certain patterns that can be divided into three categories: logistics, policy and acceptability. That said, the information above is a snapshot of the situation in several different places; it is not a systematic or controlled comparison, and it is difficult to draw definitive conclusions about causality.

There are many logistical issues to consider when planning a vaccine campaign. First, a vaccine must be authorized or approved for administration to the general population, and vaccine doses must be supplied. Scientific, political, logistical and financial factors have resulted in greater vaccine availability in some countries than in others, but few countries have sufficient vaccine supplies to cover their entire population. Awareness of inevitable supply constraints resulted in the creation of vaccine rollout plans that initially target smaller subpopulations. Now that these plans have been implemented, administration constraints, rather than supply constraints, have emerged as primary obstacles to rapid vaccine rollout. Considerations for vaccination administration include: vaccine doses must be transported to sites of administration under quality-assured, appropriately temperature-controlled conditions; there must be equipment to administer vaccines; people need to be given vaccination appointments and must be able to access administration sites; there must be enough trained personnel to register recipients, prepare and administer doses and enter data; and there must be sufficient health care personnel, equipment and space to ensure safe monitoring for adverse effects immediately after the vaccine has been administered. Bahrain is using a vaccine (BBIBP-CorV) that can be stored at the temperature of a conventional refrigerator instead of at the colder temperatures required for the Moderna and Pfizer vaccines. Israel has a quality-controlled system of transporting doses within cold boxes to vaccine administration sites that are accessible to smaller communities. West Virginia has used an existing infrastructure of local pharmacies to distribute vaccination to people that would have otherwise been harder to reach.

A policy issue that may affect the rate of vaccine uptake is the decision about which subpopulation to vaccinate for each phase of the rollout. If the eligible population is larger, overall vaccine uptake might happen faster. Israel's relatively broad initial eligibility criteria may have helped facilitate rapid scale-up of vaccine administration. However, a potential trade-off is the risk that a broad initial target population will delay access for those who may benefit most from vaccination and/or have least access to health care. There is not evidence that this has occurred in Israel, and each country's decisions may be different depending on overall population size and the relative size of at-risk subpopulations, but the potential for this trade-off must be considered. Another policy issue, touched upon earlier, is how to make sure a second dose of vaccine is available for all people who received a first dose (if the COVID-19 vaccine schedule includes two doses and if completion of a two-dose schedule is prioritized over broader rollout of first doses). The more conservate approach—only giving a person a vaccine once two doses are available—could delay vaccine rollout if doses are in short supply. The less conservative approach—relying on an expected delivery schedule of second doses—could facilitate faster vaccination but risks a delay in second dose administration. Alternatively, the United Kingdom, in the context of a rapidly spreading strain that appears to be significantly more infectious, has gone one step further and decided to delay second doses in order to quickly administer first doses more widely, an approach that has been widely debated.

Finally, a major potential barrier to the success of vaccine rollout campaigns is vaccine hesitancy. In Bahrain, Israel and West Virginia, visible and trusted public figures received their vaccines in anticipation of vaccine campaign launch dates. A June 2020 survey of 13,426 people in 19 countries reported that overall, 71.5% of participants would be very or somewhat likely to get a COVID-19 vaccine. Differences in acceptance rates between countries ranged from 55% (Russia) to 89% (China). Studies suggest vaccine hesitancy has decreased over the past few months as messaging around the safety and efficacy of the vaccines authorized for use has been disseminated. According to polls conducted by the Kaiser Family Foundation, in September only 63% of U.S. residents reported that they would accept a COVID-19 vaccine; that proportion increased to 71% in December. The same report found that hesitancy rates varied by political affiliation, age, race, and whether the person resided in an urban or rural area. Countries, states and communities have taken different approaches to combating vaccine hesitancy, and the relative success of those approaches may play an important role not just in overall population vaccine coverage, but also in the speed of vaccine rollout.

Weekly Research Highlights

PERFORMANCE OF AN ANTIGEN-BASED TEST FOR ASYMPTOMATIC AND SYMPTOMATIC SARS-COV-2 TESTING AT TWO UNIVERSITY CAMPUSES — WISCONSIN, SEPTEMBER–OCTOBER 2020

(MMWR, January 2021)

Main message: In a real-world university setting, the sensitivity and specificity of SARS-CoV-2 antigen testing (using Sofia SARS Antigen FIA) compared to PCR testing was lower than had been reported in the U.S. Food and Drug Administration emergency use authorization and lower in asymptomatic people when compared to symptomatic people. The sensitivity of the test (the percent of time a positive was correctly identified) was 80% among symptomatic individuals and only 41% among asymptomatic individuals. The specificity of the test (the percent of time that a negative result was correctly identified) was 99% among symptomatic individuals and 98% among asymptomatic individuals. Based on these results, the authors recommend that confirmatory PCR testing be conducted in symptomatic people who test negative and asymptomatic people who test positive on an antigen test.

- A total of 1,098 people were tested at two universities in Wisconsin; 227 were symptomatic at the time of their test. All participants were simultaneously given an antigen and PCR test. The overall prevalence in the population at the time of the test was relatively high (5%). Among people who were symptomatic, the likelihood that those who received a positive antigen test were truly positive (called the positive predictive value of the test) was 94%. Among those who were asymptomatic, it was only 33%.
- The negative predictive values of the test were higher. Among those who were symptomatic, the likelihood that those who had a negative antigen test result were truly negative was 96%; among those who were asymptomatic, 99%.
- Negative and positive predictive values depend on the prevalence in the community. In a community with a lower prevalence, negative predictive values would be higher and positive predictive values lower.
- The authors also attempted to grow the virus if either the PCR or antigen tests were positive. Virus was identified in 82% of the people with two positive tests (32 of 39) and in 11% of the people with a positive PCR test and negative antigen test (2 of 18; both were symptomatic). No virus was identified in people with a positive antigen and negative PCR test.
- In addition to the high negative predictive value of the antigen test in people without symptoms, the fact that the researchers were not able to culture virus in any of the asymptomatic people who had a positive PCR but negative antigen test contributed to their recommendation that confirmatory testing is not needed after a negative test in an asymptomatic person.
- Limitations: The population was largely young, white and undergoing serial testing regardless of symptoms and therefore the results may not be generalizable to all populations. Further, while PCR tests are more accurate than antigen tests, they are also imperfect, which may affect

results. Finally, this study only looked at one brand of antigen test and may not apply to other antigen tests.

ESTIMATION OF US SARS-COV-2 INFECTIONS, SYMPTOMATIC INFECTIONS, HOSPITALIZATIONS, AND DEATHS USING SEROPREVALENCE SURVEYS

(JAMA, January 2021)

Main message: Researchers estimate that by Nov. 15, 2020 there had been 46.9 million COVID-19 cases in the United States, of which 28.1 million were symptomatic. In addition, there were more than 950,000 hospitalizations and 300,000 deaths due to COVID-19. This estimate indicates that 14% of Americans had been infected with COVID-19 by Nov. 15, 2020. While this is a large proportion, it does not approach the level required for herd immunity (more than 60%). Comparing their estimates of the death toll to deaths reported as of Nov. 15, the authors estimated that 35% of COVID-19 deaths may not be reported.

- Total infections were calculated by adjusting reported infections (10.8 million) using five CDC seroprevalence surveys, covering the periods of March-August 2020, to account for underreporting.
- Data from 10 states (California, Connecticut, Florida, Louisiana, Minnesota, Missouri, New York, Pennsylvania, Utah and Washington) represented in most of the CDC seroprevalence surveys was used to generate a multiplier that captured the extent of underreporting at each of five time points.
- The authors used the following CDC estimates to determine the numbers of symptomatic people, hospitalizations and deaths:

    - 60% of patients with COVID-19 have symptoms
    - 3.4% of symptomatic patients are hospitalized
    - 0.65% of people with COVID-19 will die from it (infection fatality ratio)
- Estimated cases were on average 10.8 times higher than the number of reported cases in the first survey, declining to 3.2 by the most recent survey (see table).
- This paper provides useful estimates but the data has major limitations:
    - CDC seroprevalence surveys may not be representative of the nation as they draw mainly from 10 states and use leftover blood specimens rather than a community survey approach. However, author comparisons to community surveys showed they were not very different.
    - Waning immunity/antibodies may result in seroprevalence surveys underestimating the proportion of the population that has been infected.
    - The survey looked at the total underreporting as revealed by each survey and then applied it to a small slice of time; however, since infections are cumulative, underreporting in early months will continue to influence the data, especially in states like New York which had the bulk of infections at the beginning of the pandemic.

Table 3. Estimated SARS-CoV-2 Infections, Symptomatic Infections, Hospitalizations, and Deaths by Time Period, 2020

			Estimated, No.			
Time period	Reported cases, No.	Infection (symptomatic) underreporting multiplier	Infections	Symptomatic infections	Hospitalizations	Deaths
January 21-April 30	1 062 446	10.8× (6.5×)	11 474 417	6 905 899	234 801	74 584
May 1-May 31	725 234	4.5× (2.7×)	3 263 553	1 958 132	66 576	21 213
June 1-June 30	837 193	5.4× (3.2×)	4 520 842	2 679 018	91 087	29 385
July 1-July 31	1 917 706	3.9× (2.4×)	7 479 053	4 602 494	156 485	48 614
August 1-November 15	6 303 794	3.2× (1.9×)	20 172 141	11 977 209	407 225	131 119
Total	10 846 373	NA	46 910 006	28 122 752	956 174	304 915

Abbreviations: NA, not applicable; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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