

Critical Care Requirements Under Uncontrolled Transmission of SARS-CoV-2

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Objectives. To estimate the critical care bed capacity that would be required to admit all critical COVID-19 cases in a setting of unchecked SARS-CoV-2 transmission, both with and without elderly-specific protection measures.

Methods. Using electronic health records of all 2432 COVID-19 patients hospitalized in a large hospital in Madrid, Spain, between February 28 and April 23, 2020, we estimated the number of critical care beds needed to admit all critical care patients. To mimic a hypothetical intervention that halves SARS-CoV-2 infections among the elderly, we randomly excluded 50% of patients aged 65 years and older.

Results. Critical care requirements peaked at 49 beds per 100 000 on April 1–2 weeks after the start of a national lockdown. After randomly excluding 50% of elderly patients, the estimated peak was 39 beds per 100 000.

Conclusions. Under unchecked SARS-CoV-2 transmission, peak critical care requirements in Madrid were at least fivefold higher than prepandemic capacity. Under a hypothetical intervention that halves infections among the elderly, critical care peak requirements would have exceeded the prepandemic capacity of most high-income countries.

Public Health Implications. Pandemic control strategies that rely exclusively on protecting the elderly are likely to overwhelm health care systems. (*Am J Public Health.* 2021;111:923–926. <https://doi.org/10.2105/AJPH.2020.306151>)

The prevailing epidemiological view is that a sustainable plan for the COVID-19 pandemic requires 2 components: measures to protect vulnerable groups, including the elderly, and measures to control viral transmission in the entire population. The most extreme example of the latter measures are lockdowns, such as those instituted worldwide in spring 2020, to suppress infections to low levels, avoid the collapse of the health care system, and prepare countries to better control transmission after a lockdown. This view has been

summarized in the John Snow Memorandum.¹

The resurgence of SARS-CoV-2 in fall 2020 has led to new rounds of lockdowns, especially where systems for adequate pandemic control were not developed after the original lockdown. The resulting frustration and economic uncertainty have reawakened proposals, as summarized in the Great Barrington Declaration,² to pursue “herd immunity” through natural infection. The idea is to protect individuals at the highest risk for dying of COVID-19 while allowing those at low risk to resume their

normal lives to build up immunity to the virus through natural infection, something that would eventually protect the vulnerable.² The American Public Health Association and other public health groups have warned against this proposal³ because young people cannot be effectively isolated from the rest of society, natural infection may not provide lasting immunity,⁴ and many young people suffer serious diseases, have long-term sequelae, or die after SARS-CoV-2 infection.

An understudied implication of the herd immunity proposal is its potential

to overwhelm the health care system, which happened when SARS-CoV-2 was uncontrolled in spring 2020.⁵ In places with seroprevalence was greater than 10% during the first months of the pandemic, such as Madrid, Spain, admissions to an intensive care unit (ICU) were reported to surpass prepandemic capacity.⁶ Yet it is not precisely known what ICU capacity would have been required to care for COVID-19 patients in a setting of unchecked SARS-CoV-2 transmission if protection measures aimed at the vulnerable had been in place.

We used electronic health records from a large teaching hospital in Madrid to identify critical cases between February 28 and April 23, 2020, regardless of whether they were actually admitted to an ICU. We then estimated the number of ICU beds that would have been required to admit all critical cases with and without a hypothetical intervention to protect the elderly.

METHODS

Our study included 2432 individuals aged 16 years and older who were admitted with a COVID-19 diagnosis to La Paz University Hospital in Madrid for 24 hours or longer between February 28 and April 23, 2020. The Madrid region is divided into 15 health districts, each assigned to a major hospital. The catchment area of La Paz University Hospital encompasses 527 000 people (18.7% of them aged 65 years or older). During the study period, all Madrid hospitals were overwhelmed and could not admit patients from outside their catchment area.

La Paz University Hospital routinely maintains 30 medical ICU and 10 cardiac ICU beds, in line with the average 9.7 critical care beds per 100 000 adults in Spain⁷ and most European countries

(this is higher than in, e.g., England [10.5] and Italy [2.5], but lower than in, e.g., Germany [33.9] and the United States [25.8]).⁷ The prepandemic average ICU occupancy in Spain was about 70%,⁸ that is, an influx of COVID-19 patients greater than 30% of prepandemic capacity would strain the health care system.

In the absence of other clinical criteria supporting nonadmission, inpatients were admitted to the ICU for possible invasive mechanical ventilation when they had a capillary oxygen saturation of less than 90% (an arterial partial pressure of oxygen of approximately < 60 mmHg) despite being on a reservoir (e.g., non-rebreather) mask or noninvasive mechanical ventilation. We defined COVID-19 inpatients as needing critical care when they were either (1) admitted to an ICU, or (2) not admitted to an ICU but had at least 2 recorded saturation measurements less than 90% while on a reservoir mask or on noninvasive mechanical ventilation.

To estimate the number of ICU beds that would have been needed to admit all critical care patients, we conservatively assumed that 5 beds per 100 000 (about two thirds of the usual occupancy) would have been occupied by non-COVID-19 patients throughout the study period and that critical care patients not admitted to the ICU would have stayed at the ICU an average of 12 days until discharge or death,^{9–11} had they been admitted.

To estimate the number of ICU beds that would have been needed under a hypothetical intervention that would somehow prevent half of SARS-CoV-2 infections in the elderly, we repeated our calculations after randomly excluding 50% of patients aged 65 years or older. We used the 2.7 and 97.5 percentiles of a nonparametric bootstrap with 300 samples to quantify the

uncertainty attributable to the random exclusion of patients.

RESULTS

Of 2432 patients (57.1% aged 65 years or older) admitted to La Paz University Hospital with a COVID-19 diagnosis between February 28 and April 23, 2020, 243 (41.9% aged 65 years or older) were admitted to an ICU and an additional 69 met our criteria for critical care, for an estimated total of 312 patients (54.5% aged 65 years or older) requiring ICU admission.

The estimated number of ICU beds that would have been required to admit all critical care patients in the hospital's catchment area during the study period peaked at 49 beds per 100 000 on April 1–2 weeks after the start of a national lockdown (Figure 1a). The estimated peak would have been 39 (37–40) beds per 100 000 if a hypothetical intervention had decreased infections in the elderly by half (Figure 1b).

Figure A (available as a supplement to the online version of this article at <http://www.ajph.org>) represents ICU bed peak requirement estimates when using an 18-day ICU stay (the reported average stay for admitted patients during the study period) for nonadmitted critical care patients.

DISCUSSION

The peak ICU requirements in Madrid under uncontrolled transmission of SARS-CoV-2 were about fivefold higher than prepandemic capacity. Faced with this extraordinary demand, hospitals increased critical care capacity more than threefold by temporarily reallocating beds in coronary, surgical, and other units.⁶ Despite this massive effort, demand outpaced ICU capacity. In fact,

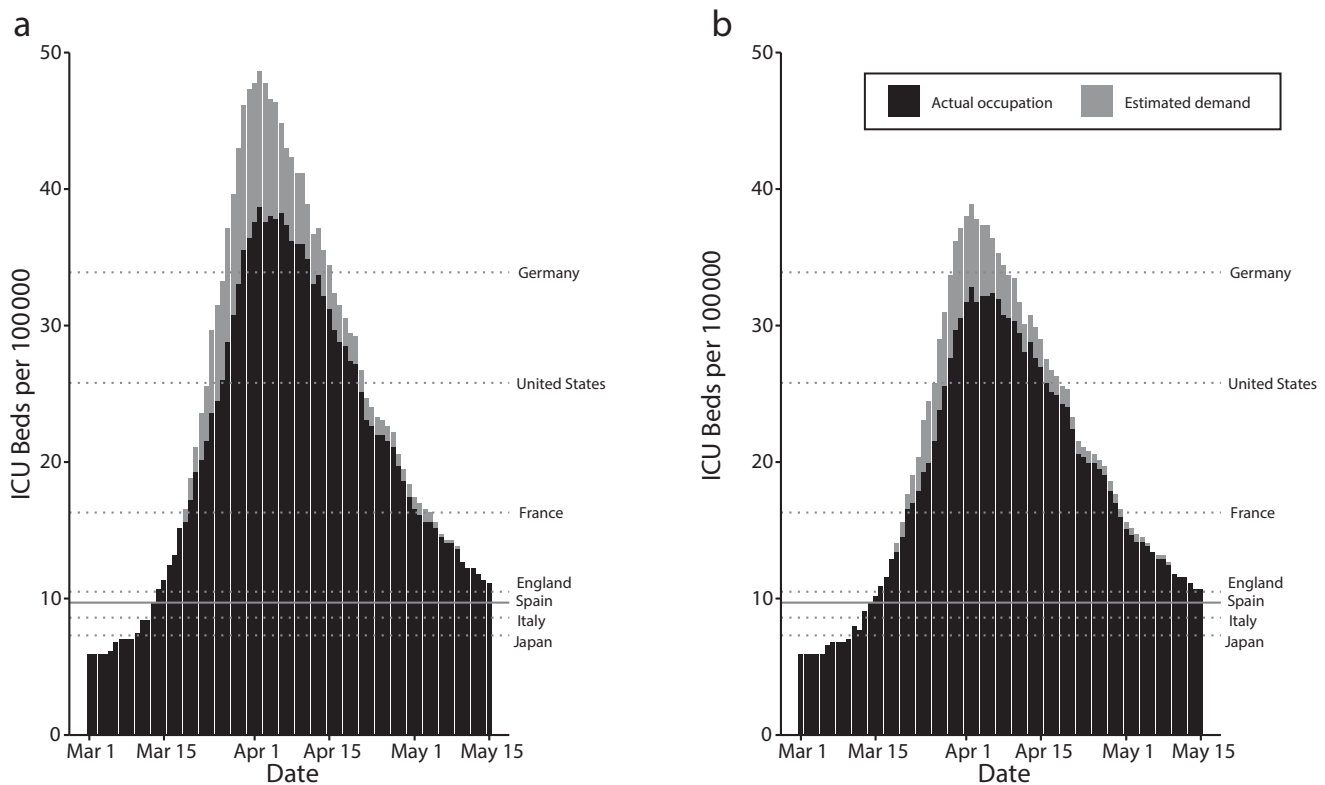


FIGURE 1— Estimated Number of Intensive Care Unit (ICU) Beds Required to Admit All Patients Requiring Critical Care in the Catchment Area of La Paz University Hospital (a) Under No Hypothetical Interventions, and (b) Under a Hypothetical Intervention That Reduces SARS-CoV-2 Infection by Half in Individuals Aged 65 Years or Older: Madrid, Spain, February 28–April 23, 2020

Note. Horizontal lines show ICU capacity in selected countries. A general lockdown was implemented in Madrid on March 14, 2020.

this level of ICU demand would have exceeded the pre-pandemic capacity of any developed country.

When we considered a hypothetical intervention—not yet specified by proponents of the herd immunity approach—that halved infections in the elderly, the estimated peak ICU demand would have been more than threefold higher than usual capacity. This ICU demand is still beyond the usual capacity of most countries, and even those with the highest number of ICU beds per capita would need to substantially expand capacity to preserve care not related to COVID-19.

Note that our analysis is likely to underestimate critical care requirements. Our estimate of 12.7% hospitalized

patients requiring ICU admission is in the lower range of those reported elsewhere.^{9–11} Also, although sole reliance on capillary oxygen saturation to determine the need for critical care may slightly overestimate ICU bed needs, our overall estimates are still conservative because (1) they are based on shorter than reported average duration of ICU stays and non-COVID-19 occupancy, (2) we excluded 162 patients who had just 1 recorded saturation greater than 90% while on a reservoir mask or noninvasive mechanical ventilation, and (3) we did not consider nonhospitalized COVID-19 patients. Our results can inform decision makers from dense metropolitan areas such as Madrid, but replication studies are required to clarify to what extent

these estimates can be transported across settings.

PUBLIC HEALTH IMPLICATIONS

With more than 80% of the population still unexposed to SARS-CoV-2 in most countries and in the absence of effective treatments for COVID-19, pandemic control strategies that rely exclusively on protection of the elderly would overwhelm the health care system. [AJPH](#)

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PUBLICATION INFORMATION

Full Citation: Martínez-Alés G, Domingo-Relloso A, Arribas JR, Quintana-Díaz M, Herrán MA. Critical care requirements under uncontrolled transmission of SARS-CoV-2. *Am J Public Health*. 2021; 111(5):923–926.

Acceptance Date: December 24, 2020.

DOI: <https://doi.org/10.2105/AJPH.2020.306151>

CONTRIBUTORS

G. Martínez-Alés, A. Domingo-Relloso, M. Quintana-Díaz, and M.A. Hernán designed the analyses. G. Martínez-Alés and M. Quintana-Díaz acquired the data. G. Martínez-Alés and M.A. Hernán conceptualized the study and drafted the brief. A. Domingo-Relloso processed the data and implemented the analyses. All authors contributed to study design and interpretation of results and reviewed, revised, and approved the brief.

CONFLICTS OF INTEREST

The authors report no conflicts of interest relevant to this study.

ACKNOWLEDGMENTS

A. Domingo-Relloso was supported by a fellowship from "La Caixa" Foundation (ID 100010434, fellowship code LCF/BQ/DR19/11740016).

This work was possible thanks to the heroic efforts of workers from La Paz University Hospital during the COVID-19 pandemic. Members of the COVID@HULP group are listed in Appendix A (available as a supplement to the online version of this article at <https://www.ajph.org>).

HUMAN PARTICIPANT PROTECTION

This study was approved by the La Paz University Hospital's institutional review board.

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