



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Hospital El Salvador: a novel paradigm of intensive care in response to COVID-19 in central America



On March 18, 2020, the first case of COVID-19 was confirmed in El Salvador.¹ Closely monitoring pandemic trends worldwide,²⁻⁴ local experts realised that if El Salvador's cases were to mirror global trends, 20% of people infected with severe acute respiratory syndrome coronavirus 2 would require hospitalisation, and between 5% and 8% would require an ICU bed.⁵ Yet there were only 94 ICU beds in the public health system, distributed between nine hospitals (1.45 ICU beds per 100 000 people). By March 18, the occupancy rate was already 80%, meaning that only 19 ICU beds were available for critically ill patients with COVID-19 across the country. The profound risk associated with this low bed capacity was highlighted by experiences in Italy, which has 8.42 ICU beds per 100 000 people,⁶ and yet still had a massive stress put on its health-care system when demand surpassed supply during an early surge of cases of COVID-19.

To avert the upcoming crisis, it was urgent to increase ICU bed capacity and the reach of critical care specialists. After multiple consultations with public health officials and international agencies, the government decided to build an entirely new hospital exclusively for patients with COVID-19: Hospital El Salvador. Creating Hospital El Salvador represents a unique approach, as most countries in the region opted to set up temporary hospitals.

Hospital El Salvador was built using the existing infrastructure of the International Center for Fairs and Conventions of El Salvador. The hospital used two of the convention centre's pavilions for hospital beds, two for administration, and two for warehouses. The hospital has three emergency entrances for patients referred from different hospitals across the entire health care system. It also has two 15 000-gallon oxygen tanks to ensure oxygen supply to the remodelled pavilions. A negative pressure pavilion was set up to remove infectious particles from the ICU. Each ICU bed was fitted with a vital signs monitor, access to continuous oxygen flow, and a high-flow-capacity ventilator. The beds in both pavilions are monitored through cameras with a fibre optic connection, which feed images to the central monitoring hub at the hospital.

The monitoring hub is based on pilot work done at the original COVID-19 care hospital in El Salvador: San Rafael Hospital. San Rafael had only three staff trained in critical care and three residents in training, and that human resource capacity quickly proved insufficient. Thus, the intensive care team and administrators at San Rafael completely reorganised the ICU, developing a telemedicine-based ICU patient monitoring system with cameras, open-source digital platforms, and phones so that intensive care clinicians could direct internal operations from a distance. Through the video monitoring system, one single intensive care physician could supervise the medical staff in the entire ICU area. The monitoring system would also reduce specialists' infection risk. Test results and patient observations were entered into a dedicated form from which risk scores and indices (APACHE score, risk of death, neutrophil to lymphocyte ratio, and others) could be calculated. A traffic light triage system was then developed. These data were linked to other public network hospitals, allowing critical care specialists to exchange patient management information in real-time.

By May, 2020, COVID-19 cases were growing exponentially in El Salvador. In response, Hospital El Salvador construction progressed in phases; by

Published Online
December 23, 2020
[https://doi.org/10.1016/S2214-109X\(20\)30513-1](https://doi.org/10.1016/S2214-109X(20)30513-1)

This online publication has been corrected. The corrected version first appeared at [thelancet.com/lancetgh](https://www.thelancet.com/lancetgh) on February 26, 2021



Figure: Patient monitoring using telemedicine
Photo by Gabriela Galdamez, Hospital El Salvador.

June, 105 new ICU beds were made available, more than doubling the country's existing capacity. Additionally, San Rafael Hospital's multidisciplinary team was transferred to the new Hospital El Salvador. By July, 2020, another 143 intermediate care beds were opened, which could be converted into ICU beds if the need arose. When the first wave of the pandemic reached over 400 cases on July 22, these added ICU and intermediate care beds had a crucial role in preventing the public system from overflowing.

Based on the pilot telemedicine model, 18 critical care specialists and 25 internal medicine physicians monitored 105 ICU beds and 143 intermediate care beds 24 h per day, through high resolution pan-tilt-zoom camera systems, with access to all vital signs and overall state of patients (figure). These physicians communicated with 318 front-line general practitioners (157 in the ICU and 161 in intermediate care) and with 492 nurses (251 in ICU and 241 in intermediate care) following indications from the central hub at the hospital. These physicians were physically located at Hospital El Salvador and communicated with front-line health-care providers.

Hospital El Salvador was the first hospital with a negative pressure ICU in El Salvador and currently has 200 high-flow nasal cannulae (HFNC) machines. Pioneering this type of respiratory support in the country was a vital addition to patient care as HFNC might delay the need for intubation or ventilator use. In addition to the ICU and intermediate care beds, Hospital El Salvador added 731 hospital beds to care for patients with stable COVID-19. These beds can also be transformed into ICU beds if needed.

Hospital El Salvador protocols were developed thanks to the support of medical experts in El Salvador, and from the Salvadoran diaspora that joined efforts with an international professional network. Equipment,

infrastructure, and clinical staff training efforts were possible thanks to the solidarity of the Japan International Cooperation Agency and the United States Agency for International Development, among others.

We were motivated to write this Comment after reading Richard Horton's *Offline*.⁷ We are grateful for our courageous health-care workers and international allies. Precarious pre-COVID-19 conditions in our health system did not stop us. We remain vigilant, as we are aware of the long road ahead.

MS was hired as a medical writer by Hospital El Salvador to help write this Comment. By virtue of their roles within a public hospital or the Ministry of Health, MB, LC, WH, and XS are government employees. All other authors declare no competing interests. The findings and conclusions in the Comment are only those of the authors.

Copyright © 2020 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY-NC-ND 4.0 license.

*Manuel Bello, Víctor Segura, Luis Camputaró, William Hoyos, Mauricio Maza, Xochitl Sandoval, *Magdalena Serpa, Craig M Coopersmith*
magdalena.serpa@cuaanschutz.edu

El Salvador Hospital, San Salvador, El Salvador (MB, LC); 81 y 83 Centro Médico Escalón, San Salvador, El Salvador (VS); Ministry of Health of El Salvador, San Salvador, El Salvador (WH); Basic Health International, San Salvador, El Salvador (MM); National Institute of Health, San Salvador, El Salvador (XS); Center for Global Health, Colorado School of Public Health, Aurora, CO 80045, USA (MS); Department of Surgery and Emory Critical Care Center, Emory University, Atlanta, GA 30322, USA (CMC)

- 1 WHO. Global: El Salvador. 2020. <https://covid19.who.int/region/amro/country/sv> (accessed Dec 14, 2020).
- 2 Huang C, Wang Y, Li X, Ren L et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; **395**: 497–506.
- 3 WHO. Pneumonia of unknown cause — China. 2020. <https://www.who.int/csr/don/05-january-2020-pneumonia-of-unknown-cause-china/en/> (accessed Oct 15, 2020).
- 4 Liew MF, Siow WT, MaLaren G, et al. Preparing for COVID-19: early experience from an intensive care unit in Singapore. *Crit Care* 2020; **24**: 83.
- 5 Anesi G. Coronavirus disease 2019 (COVID-19): critical care and airway management issues. 2020. <https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-critical-care-and-airway-management-issues> (accessed Oct 15, 2020).
- 6 European Observatory on Health Systems and Policies. 2020. <https://www.covid19healthsystem.org/countries/italy/livinghit.aspx?Section=2.2%20Workforce&Type=Chapter> (accessed Oct 31, 2020).
- 7 Horton R. *Offline: Reasons for hope*. *Lancet* 2020; **396**: 105.