ISARIC-COVID-19 dataset: A Prospective, Standardized, Global Dataset of Patients Hospitalized with COVID-19

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The International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC) COVID-19 dataset is one of the largest international databases of prospectively collected clinical data on people hospitalized with COVID-19. This dataset was compiled during the COVID-19 pandemic by a network of hospitals that collect data using the ISARIC-World Health Organization Clinical Characterization Protocol and data tools. The database includes data from more than 705,000 patients, collected in more than 60 countries and 1,500 centres worldwide. Patient data are available from acute hospital admissions with COVID-19 and outpatient follow-ups. The data include signs and symptoms, pre-existing comorbidities, vital signs, chronic and acute treatments, complications, dates of hospitalization and discharge, mortality, viral strains, vaccination status, and other data. Here, we present the dataset characteristics, explain its architecture and how to gain access, and provide tools to facilitate its use.

Background & Summary
The International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC) is a global federation of clinical research networks collaborating to prevent illness and death from infectious disease outbreaks through proficient and agile research response¹. In January 2020, ISARIC launched a research response to the emergence of a novel severe acute respiratory syndrome coronavirus (SARS-COV-2), detected weeks earlier in Wuhan, China²,³. The initial focus was on the clinical characterisation of COVID-19, the disease caused by SARS-CoV-2, which mainly affects the respiratory system⁴. The fatality rate of COVID-19 varies substantially across different locations, which may reflect differences in population age, comorbidities, vaccination status, and other factors⁵. In June 2022, there were more than 500 million reported cases and more than 6 million deaths. Despite unprecedented success in the rapid generation of vaccines and effective treatments, COVID-19 continues to cause severe and widespread health consequences⁶,⁷. Therefore, the continuation of high-quality, globally-representative research is critical – as are the data required to deliver it.

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At the beginning of the COVID-19 outbreak, ISARIC adapted the ISARIC-WHO Clinical Characterization Protocol and data tools\(^7\) to facilitate global research collaboration and accelerate the understanding of COVID-19 as part of the public health response to the pandemic\(^8,9\). Between January 2020 and September 2021, information about the clinical presentation, treatment, and outcomes of more than 705,000 patients with COVID-19, hospitalized across 62 countries, was aggregated to form the ISARIC-COVID-19 dataset. Clinical teams in 1,559 participating institutions collected the data. Figure 1 shows the number of patients per country included in the database as of September 2021\(^1,4,10\). The number of patients included in the dataset continues to grow as data collection continues across the globe.

The objective of the dataset is to accelerate understanding of COVID-19 through access to detailed clinical information on infected patients from a range of settings. Access to data facilitates science, improves scientific transparency and integrity, and has played a substantial role in the generation of knowledge that has led to better patient management and vaccine production for COVID-19\(^11\). The diversity of populations, regions, and resource levels from which the data originate increases the generalizability of the evidence generated and supports comparisons across them. By collating, standardizing, and sharing large volumes of disparate data, curation and governance efforts are invested centrally by a specialised team, enabling efficient data access, and analysis by many researchers focused on the questions most relevant to the patients in their settings. This approach accelerates pandemic response by promoting locally-driven, locally-relevant knowledge generation, which is most likely to have an impact on public health policy and drive societal benefits beyond health\(^12,13\).

**Methods**

**Data collection.** Standardized clinical data of patients with suspected or confirmed COVID-19 are collected on the ISARIC-WHO case report forms (CRFs) ([https://isaric.org/research/covid-19-clinical-research-resources/covid-19-crf/](https://isaric.org/research/covid-19-clinical-research-resources/covid-19-crf/)) or site-specific iterations of these forms. These forms are available in multiple languages to support accessibility for a global response.

Sites implement data collection contemporaneously to clinical care. Data are collected through direct observation and/or reviewing and extracting electronic health records or patient registries. Data can be submitted to ISARIC by completing the CRF on the Research Electronic Data Capture platform (REDCap version 10.6 Vanderbilt University\(^14\)) hosted by the University of Oxford. Alternatively, institutions using other data collection forms and/or a different data management system can share patient data in any format to the ISARIC COVID-19 data platform, hosted by the Infectious Diseases Data Observatory (IDDO, [www.iddo.org](http://www.iddo.org)). Data were prospectively collected on patients with clinical suspicion or laboratory confirmation of SARS-CoV-2 infection and admitted to a participating hospital or ward. Recruitment aimed to include all identified patients; however, resource constraints limited enrolment when patient numbers surged and health systems became overwhelmed. In such cases, or in sites where prospective data collection was impossible, data were extracted from electronic health records. Ethics approval and informed consent were obtained according to local regulations, which included a waiver of consent to collect de-identified data at several sites due to the burden on front-line
workers and the data protection framework in place. The WHO-ISARIC Clinical Characterization Protocol was approved by the WHO Ethics Committee (RPC571 and RPC572).

**Data standardization.** The ISARIC COVID-19 dataset is a large, clinically comprehensive, international resource. The diversity of data aggregated to create this resource required a uniform data model to standardize the structures and ontologies to a harmonized format. Thus, all data are standardized to the Clinical Data Interchange Standards Consortium (CDISC) Study Data Tabulation Model (SDTM) to facilitate pooled analyses. While there is no perfect data model, the CDISC SDTM was chosen to allow maximum flexibility to accommodate the diverse data types collected by different groups. This was preferred over other options, such as the Observational Medical Outcomes Partnership (OMOP) model, which was more rigid with a fixed number of possible tables and variables. The use of SDTM also allows for greater interoperability to enable integration with COVID-19 clinical trial data that may be added to the dataset in the future. This data model is designed for data tabulation and storage. Using the dataset requires processing to create an analysis dataset from which results can be derived. Here we present a complete description of the available data, how it is formatted, and describe a generalizable strategy to use and maximize its utility in research.

**Data standardization - de-identification.** Data entered in the ISARIC REDCap database or uploaded to the IDDO data platform are reviewed to ensure no direct identifiers are included. Direct identifiers, including those listed in the UK General Data Protection Regulation (https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/) and the US Health Insurance Portability and Accountability Act (https://www.hhs.gov/hipaa/index.html), are permanently deleted before data are curated through various processes.

**Data standardisation - pre-mapping.** Data and all documentation shared with the data, such as dictionaries, protocols, publications, and data collection forms, are reviewed by the data curator to fully understand the contents of the dataset. Queries are raised with the data contributor when required. Each variable in the dataset is assigned to the appropriate SDTM domain(s), variable(s), and controlled vocabulary (if applicable) according to the rules found within the IDDO SDTM Implementation Manual (https://www.iddo.org/tools-and-resources/data-tools). The implementation manual chronicles each type of data curated to the platform and is consulted and updated with each new dataset to ensure consistency across the repository. An audit trail of the assignments is also recorded in a dataset-specific SDTM mapping guide.

**Data standardization - data wrangling.** For formatting and coding, the contributed datasets are loaded into Trifacta®, a data wrangling programme. This can include merging files, splitting variables into separate domains, applying controlled terminology to variables, and adding created variables as required. IDDO-defined standardization, conversion, and categorization formulas are also used as described in the IDDO SDTM Implementation Manual. Transformations on the contributed data (in the interests of standardization) are recorded and stored in a form that documents the transformation and enables it to be reproduced.

**Data standardization - review and edit checks.** Data is run through Pinnacle 21® (community version) software, a CDISC standards compliance-verification tool that checks the standard SDTM implementation guide rules and requirements for regulatory submission. The resulting checks and warnings are assessed for applicability to the individual dataset. The data are also run through standard edit checks to identify possible mapping errors separate from SDTM conformance. The curator adjusts the mapping as needed to make corrections.

Figure 2 describes the workflow from data acquisition to the final, pooled dataset that researchers can access to conduct their research.

**Data Records**

The dataset is available from the Infectious Diseases Data Observatory – IDDO at https://doi.org/10.48688/nx85-bv3015 The ISARIC-COVID-19 dataset is a relational database consisting of 16 tables, each representing a domain of information set out in the CDISC SDTM data model. Unique identifiers link these with the suffix ‘ID’. For example, USUBJID refers to the subject’s unique identifier, which is the primary key for assessing individual-level data; STUDYID contains the unique identifier for an individual hospital or network of hospitals. Each table defines and tracks different aspects of illness and treatment.

**Data tables.** The tables (i.e., domains) currently included in the dataset are Demographics (DM), Disposition (DS), Environmental Risk (ER), Healthcare Encounters (HO), Inclusion/Exclusion Criteria (IE), Treatments and Interventions (IN), Laboratory Results (LB), Microbiology Specimen (MB), Reproductive System Findings (RP), Disease Response and Clinical Classification (RS), Clinical and Adverse Events (SA), Subject Visits (SV), Vital Signs (VS), COVID-19 Follow-Up questionnaire (CQ), Subject Characteristics (SC), and Pregnancy Outcomes (PO) (Supplementary Table 1); the majority of those tables are at a patient level, so it has a subject id (USUBJID) that relates the information of a single patient distributed in the multiple tables. The Trial Summary (TS), Trial Inclusion Exclusion Criteria (TI), and Device Identifiers (DI) are study-level domains; thus, there is no individual patient-level data in those domains. Instead, there is information about the uniqueness of each institution, for instance, the inclusion/exclusion criteria or the devices used at each hospital. Data collection times for each data type are presented in Fig. 3. As an example, we show in Fig. 4 a synthetic, representative subset of the available data for a female patient.

The CDISC SDTM data model has several advantages. For example:
It can adapt to any number of events. Frequently recorded events such as vital signs, laboratory tests, and patient status scores are stored as a series of events. The order is recorded in the variables with the suffix ‘DY’, which describes the day of the observation relative to the patient’s hospital admission date. For example, the variable ‘VSDY’ indicates the day when a particular vital sign was measured. Events occurring within the same day can be further ordered using the variables with the suffix ‘SEQ’, which captures the sequence of events independently of the day on which they occurred.

It captures whether or not a variable was collected for a given patient (this is critical to count denominators accurately in an aggregated collection of many different datasets). The model enables this by collecting the existence of a variable separately from the occurrence or completion of that variable. E.g., if the CRF for a dataset includes data on fever, the model shows that this question was prespecified as FEVER_PRESP = Yes; if the patient had a fever, it is captured as FEVER_OCCUR = Yes; if the patient was afebrile, it is registered as FEVER_OCCUR = No. Combining these two variables makes it possible to accurately quantify how many patients were evaluated for fever and how many had a fever. This distinction is found in the ER, HE, IN, and SA tables. A full description of how SDTM is implemented for these data, Frequently Asked Questions, and other data tools are available within the IDDO suite of curation and data resources (https://www.iddo.org/tools-and-resources/data-tools) to assist analysts in understanding these nuances.

The remaining tables contain study-level data (e.g., Study Inclusion Exclusion Criteria and Device Identifiers); thus, there are no individual-level data in these domains.

The dataset also contains a rich repository of free-text entries that capture more fine-grained information not included in the CRF solicited entries. Such information can be identified by applying simple search functions or Natural Language Processing (NLP) techniques to the **TERM variable. Supplementary Table 1 describes how data is distributed across the domain data tables and how many unique patients are included in each table.
Patient characteristics. Among the 708,158 patients whose data were entered as of September 2021, 552,366 (78%) had laboratory confirmation of SARS-CoV-2 infection, and 50,426 (7%) were clinically diagnosed (where testing was not available or results were not reported). Of these patients, the median age (interquartile ranges: first quartile (Q1) and third quartile (Q3)) is 58 (IQR: 44–72) years, 48.9% are male, and 50.9% are female (the sex of 0.1% of the patients is unknown). A total of 126,069 (20.9%) patients were admitted to a critical care unit (ICU or HDU), and in-hospital mortality was 23.5%. Table 1 provides a breakdown of the population by continent, and Supplementary Table 1 shows the number of unique patients with data reported per each domain.

The most frequently reported comorbidities, symptoms at hospital admission, and complications during hospital admission are presented in Fig. 5. Among comorbid conditions, hypertension (30.7%), diabetes mellitus (29.6%), and chronic cardiac disease (10.5%) were the most frequently reported. The top five symptoms
The teams performing analyses can develop analytic codes based on assumptions they deem appropriate. Data transformations are made during the database construction process, care is taken not to modify raw study data with scripts to help import the data into PostgreSQL and codes that enable the reuse of the data. Notably, where ISARIC COVID-19 database is provided as a collection of comma-separated value (CSV) files (i.e., tables), along with ISARIC and IDDO data management teams. When shared through the governed data access mechanisms, the ISARIC-COVID-19 dataset can generate insights facilitating quality control measures, especially in developing countries where scarce scientific resources.

### Table 1. Details of the ISARIC-COVID-19 patient population by continent. The information presented in the table is based on the raw data, and there is missing data, for instance: 470 patients do not have their country of origin registered; 8143 patients do not have age; 149 do not have their sex registered, and the outcome of 10130 patients is missing.

| Continent       | Global | Africa | Europe | Asia | North America | South and Central America | Oceania |
|-----------------|--------|--------|--------|------|---------------|---------------------------|---------|
|                 | n = 602792 | n = 369467 | n = 206992 | n = 16019 | n = 6687 | n = 2709 | n = 448 |
| Critical care admission, counts (%)          | 126069 (20.91) | 73095 (19.78) | 35454 (17.13) | 11544 (72.06) | 3619 (54.12) | 1872 (69.10) | 427 (95.31) |
| Age, years, median (Q1-Q3)                   | 58 (44–72) | 54 (40–66) | 70 (54–82) | 58 (46–68) | 64 (52–76) | 54 (42–66) | 62 (51–70) |
| Male, counts (%)                             | 294928 (48.93) | 165376 (44.76) | 113148 (54.66) | 10366 (64.71) | 3857 (57.68) | 1659 (61.24) | 269 (60.04) |
| In-hospital mortality, counts (%)            | 141646 (23.5) | 88737 (24.02) | 46424 (22.43) | 4310 (26.91) | 1672 (25) | 440 (16.24) | 59 (13.17) |

Data at admission were cough (23.7%), shortness of breath (19.8%), fever (17.5%), fatigue (11.5%), and altered consciousness (6.1%). Regarding complications, viral pneumonia (16.2%), acute respiratory distress syndrome (6.6%), acute kidney injury (5.5%), anaemia (4.3%), and bacterial pneumonia (3.8%) were the most frequently identified.

### Technical Validation

Data submitted via the ISARIC REDCap system are subjected to a series of field-specific data quality checks designed by ISARIC. These trigger error alerts inform users of issues based on value limits, validate dates, flag missing variables, and perform logic checks to compare related variables. Data are further reviewed by a data manager who sends data quality reports and queries to sites when critical data are missing or outside expected values. Staff at data collection sites review the alerts and make the necessary corrections to their data in the REDCap system.

Data uploaded to the IDDO platform are verified during the ‘pre-mapping’ and ‘data review and edit checks’ processes described above. Interpretation of the data dictionary (for sites that used a unique data collection tool) and any missing values are queried directly with staff at the data collection sites. Results are charted per variable to identify and query outlier values. Where correction is suggested, the contributing site is contacted and asked to correct the data as needed before re-uploading them to the data platform.

### Usage Notes

The utility of the data collected is optimised by issuing regular open-access ISARIC COVID-19 Clinical Data Reports (https://isaric.org/research/covid-19-clinical-research-resources/evidence-reports/) and periodic updates to the ISARIC COVID-19 Dashboard (https://livedataoxford.shinyapps.io/CovidClinicalDataDashboard/). Data are available for analysis through two mechanisms to maximize uptake: a collaborative mechanism for ISARIC partners who contribute data to the dataset and a data-sharing platform for external researchers. The sites that contribute to the data retain ownership and decision-making authority on their data at all times.

It is essential to highlight that more countries are globally transitioning to digital-based healthcare systems. During the transitioning process, quality control measures are necessary to enhance the effectiveness of healthcare-related communication and data quality\(^\text{16}\). Thus, the ISARIC-COVID-19 dataset can generate insights facilitating quality control measures, especially in developing countries where scarce scientific resources.

### Data access.

Staff from sites that contribute data to the dataset may access data for collaborative analysis via the ISARIC Partner Analysis scheme (https://isaric.org/research/isaric-partner-analysis-frequently-asked-questions/). Proposals for these analyses are governed and supported by ISARIC and executed with all data contributors’ contributions, oversite, and accreditations\(^\text{16,20}\). ISARIC provides statistical, clinical, and administrative support to promote analyses by partners who contribute the data, especially those based in low-resource settings.

External researchers who have not contributed to the dataset are also welcome to submit a data access and analysis proposal via the IDDO platform (https://www.iddo.org/covid19). An independent Data Access Committee reviews these requests according to the Data Access Guidelines of the platform (https://www.iddo.org/covid19/data-sharing/accessing-data). Statistical analysis plans and outputs from both types of access can be viewed at: https://www.iddo.org/covid19/research/approved-uses-platform-data.

Data management, curation, governance, and the data-sharing platform are free to use and supported by the ISARIC and IDDO data management teams. When shared through the governed data access mechanisms, the ISARIC COVID-19 database is provided as a collection of comma-separated value (CSV) files (i.e., tables), along with scripts to help import the data into PostgreSQL and codes that enable the reuse of the data. Notably, where data transformations are made during the database construction process, care is taken not to modify raw study data. The teams performing analyses can develop analytic codes based on assumptions they deem appropriate.

### Data use.

The breadth of analyses published to date demonstrates the diversity of science that can be generated from these data. Examples include identification of unique COVID-19 symptomology at the extremities of age\(^\text{16}\); to develop the ISARIC 4 C mortality score that outperformed existing scores and showed utility to directly...
inform clinical decision making\textsuperscript{22}; to identify temporal trends in inpatient journeys and inform resource needs in an evolving pandemic\textsuperscript{10}, and to improve the diagnosis of acute kidney injury\textsuperscript{23}. Further analyses to develop natural language processing, understand neurological outcomes in COVID-19 and develop models that predict a range of outcomes.

The use of such a large and diverse dataset is not without challenges. Robust interpretation of analytic outputs requires an understanding of the variation in recruitment practices between sites and during the course of the outbreak and the availability of treatments and facilities (e.g., ICUs and ventilators) across the range of resource settings. ISARIC’s collaborative approach to research outputs addresses these challenges by involving all staff who contributed to the collection of data in the review of the analysis plans and manuscripts. When designing an analysis plan, researchers must also consider which data are and are not available from each site and account for high levels of missingness, particularly during regional peaks in COVID-19 transmission. The CDISC SDTM data model was selected for harmonisation of these data, specifically because it captures these aspects of data providence. Those using the dataset benefit from the richness of the model; however, they will need to master the challenges of its complexity. Tools to support understanding of the data model can be found at \url{https://www.iddo.org/tools-and-resources/data-tools}.

Collaborative research. The ISARIC WHO characterization protocol has proven to be a successful strategy for generating standardized data from multiple sites that international researchers can access for analysis\textsuperscript{18,21,22,24–27}. Having a pre-prepared protocol for clinical investigation of an emerging infectious disease established before the beginning of the COVID-19 pandemic allowed us to gather patient data very early in the pandemic. As a result, contributors benefited from clinical data captured in other regions before they experienced cases and improved confidence in a larger dataset. By implementing systems to harmonize global data, ISARIC and IDDO have made international collaboration more efficient\textsuperscript{1}. The evolution of these systems, including integrating epidemiological and genomic data to address new types of research questions, is in progress. Finally, ISARIC’s data governance model allows members and non-members to propose research questions that could be answered using this dataset, which has helped advance science and empowers scientists worldwide\textsuperscript{4,10,20}. This open and collaborative approach maximizes the scientific utility and public health impact of global data. With a focus on ensuring the representation of patient data and researchers from lower-resourced settings, the ISARIC network has accelerated understanding of COVID-19, advanced preparedness for future pandemics, and raised the bar on global collaboration for health.

Code availability
Processing codes for the ISARIC COVID-19 database are openly available online, and contributions from the research community to share these codes are encouraged. For this reason, a public code repository has been created along with this manuscript to develop and share code collectively: \url{https://github.com/ISARICDataPlatform/ISARICBasics.git}. The content of this repository is under continuous development. Still, it has been seeded with code to generate patient-level datasets suitable for statistics and machine learning research, such as patient demographic, comorbid conditions at the time of admission, application of treatments, and severity scores, among others. It is possible for the research community to directly submit updates, improvements, and additions to the repository via GitHub. Moreover, a Jupyter Notebook containing the code used to generate the tables and descriptive statistics included in this paper is openly available on GitHub.

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\textbf{Fig. 5} Distribution of primary symptoms, comorbidities, and treatments. (A) shows the prevalence of comorbidities; (B) shows the prevalence of symptoms at admission; (C) shows the proportion of patients receiving each treatment.

A

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Condition & Yes & No \\
\hline
Hypertension & 6323 & 182590 \\
Diabetes & 13025 & 180704 \\
Other Relevant Risk Factor & 9533 & 181996 \\
Chronic Cardiovascular Disease & 8416 & 186783 \\
Smoking & 9538 & 187701 \\
Obesity & 4181 & 194998 \\
Anemia & 4077 & 196796 \\
Chronic Pulmonary Disease & 33623 & 191034 \\
Chronic Kidney Disease & 9207 & 187641 \\
HIV/AIDS & 2522 & 189742 \\
\hline
\end{tabular}
\end{table}


\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Condition & Yes & No \\
\hline
Viral Pneumonia & 3714 & 199960 \\
Anemia & 3692 & 199297 \\
Bacterial Pneumonia & 29760 & 189903 \\
Pyrexia & 5184 & 189917 \\
Other Complication & 4279 & 194933 \\
ARDS & 3605 & 177438 \\
Cardiac Arrhythmia & 1396 & 204490 \\
Liver Dysfunction & 1168 & 203329 \\
Acute Kidney Injury & 1065 & 179517 \\
Neural Dysfunction & 2957 & 198152 \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Condition & Yes & No \\
\hline
Shortness Of Breath & 7557 & 200314 \\
Cough & 10969 & 199271 \\
Fever & 8035 & 199271 \\
Fatigue & 18856 & 187132 \\
Confusion & 10657 & 207954 \\
Vomiting/Regurgitate & 7538 & 201214 \\
Muscle Aches/Joint Pain & 7537 & 207954 \\
Diarhea & 7537 & 207954 \\
Obst Pains & 7537 & 207954 \\
Hemoptysis & 7537 & 207954 \\
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\end{table}
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Competing interests
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HCL, Lyon, France. 129 The Centre hospitalier universitaire Sainte-Justine, Montreal, Canada. 130 Rio Hortaega University Hospital, Valladolid, Spain. 131 Jena University Hospital, Jena, Germany. 132 Centre Hospitalier Universitaire Mitterrand Dijon-Bourgogne, Dijon, France. 133 National Institute for Communicable Diseases, Johannesburg, South Africa. 134 Ziekenhuissgroep Twente, Hengelo, Netherlands. 135 Hôpital Bichat Claude-Bernard AP-HP, Paris, France. 136 University Hospital Dusseldorf, Dusseldorf, Germany. 137 Centre Hospitalier Universitaire de Saint-Étienne, Saint-Étienne, France. 138 Hôpital Avicenne, Bobigny, France. 139 Centre hospitalier de l’université de Montréal, Montréal, Canada. 140 Centre Hospitalier de Bourg-en-Bresse, Bourg-en-Bresse, France. 141 Centre Hospitalier Universitaire de Besançon, Besançon, France. 142 Centre Hospitalier Universitaire Grenoble-Alpes, Grenoble, France. 143 Centre Hospitalier Universitaire de Nantes (Hôtel-Dieu), Nantes, France. 144 Hôpital d’Instruction des Armées Bègin, Saint-Mandé, France. 145 Franciscus Gasthuis & Vlietland, Rotterdam, Netherlands. 146 National Institute of Infectious Disease Evandro Chagas, Oswaldo Cruz Foundation (INI-FIOCRUZ), Ministry of Health, and D’Or Institute of Research and Education (IDOR), Rio de Janeiro, Brazil. 147 Centre Hospitalier de Mayotte, Mamoudzou, Mayotte. 148 Hospital Egas Moniz, Lisboa, Portugal. 149 Ospedale Molinette, Torino, Italy. 150 Cork University Hospital, Cork, Ireland. 151 Beacon Hospital, Dublin, Ireland. 152 Nelson Hospital, Nelson, New Zealand. 153 Cleveland Clinic, Weston, USA. 154 Medical University of Vienna, Vienna, Austria. 155 University del Cauca, Cauca, Colombia. 156 Sechenov University, Moscow, Russia. 157 Universitá Cattolica del Sacro Cuore, Rome, Italy. 158 Monash University, Melbourne, Australia. 159 Clinica Universidad de La Sabana, Chía, Colombia. 160 Centre Hospitalier Universitaire de Martinique, Fort-de-France, Saint Martin, France. 161 Centre Hospitalier Régional Metz-Thionville, Metz, France. 162 Emory University Healthcare System, Atlanta, USA. 163 Johns Hopkins, Baltimore, USA. 164 Comissão de Ética - Unidade Local de Saúde de Matosinhos, Porto, Portugal. 165 Presbyterian Hospital Services, Alberquerque, USA. 166 Hospital del Mar, Barcelona, Spain. 167 Reina Sofia University Hospital, Cordoba, Spain. 168 Hospital Espírito Santo de Évora, Évora, Portugal. 169 Hôpital Américain de Paris, Neuilly-sur-Seine, France. 170 Vancouver Island Health, Vancouver, Canada. 171 Centre Hospitalier Métropole Savoie, Chambéry, France. 172 University Hospital - Limerick, Limerick, Ireland. 173 Centro Hospitalar e Universitário de Coimbra - Hospital Pediátrico, Coimbra, Portugal. 174 Centre Hospitalier de Béziers, Béziers, France. 175 Hospital São Francisco Xavier, Lisboa, Portugal. 176 Policlinicodì Orsola Universitástità Bologna, Bologna, Italy. 177 Hospital du Sacre Coeur, Montreal, Canada. 178 Hospital Universitari Sagrat Cor, Barcelona, Spain. 179 Centre Hospitalier de Melun, Melun, France. 180 Sunnybrook Health Sciences Centre, Toronto, Canada. 181 Hôpital Kremlín-Bicêtre, Le Kremlín-Bicêtre, France. 182 Centre Hospitalier Universitaire Rennes (Hôpital Pontchaillou), Rennes, France. 183 Hôpital Tenon AP-HP, Paris, France. 184 Pakistan Kidney & Liver Institute, Lahore, Pakistan. 185 University of Guadalajara Health Sciences Center, Guadalajara, Mexico. 186 National Taiwan University Hospital, Taipei City, Taiwan. 187 Hôpital Saint-Antoine AP-HP, Paris, France. 188 National Institutes of Health (NIH), Ministry of Health Malaysia, Setia Alam, Malaysia. 189 Ospedale San Paolo, Milan, Italy. 190 Chonnam National University Hospital, Dong-gu, South Korea. 191 Pulau Pinang Hospital, Pulau Pinang, Malaysia. 192 Sunway Medical Centre, Selangor, Malaysia. 193 University
Hospital Virgen del Rocio/Institute of Biomedicine of Seville, Seville, Spain. 194 University of Utah, Salt Lake City, USA.

Children's Health Ireland, Dublin, Ireland. 195 Foothills Medical Centre, Calgary, Canada. 196 Connolly Hospital Blanchardstown, Dublin, Ireland. 197 Carilion Clinic, Roanoke, USA. 198 Centre Hospitalier Départemental Vendée, La Roche-sur-Yon, France. 199 Allegheny General Hospital, Pittsburgh, USA. 200 Fondazione IRCCS Ca, Milan, Italy.

University of Queensland, Brisbane, Australia. 201 Centre Hospitalier Bretagne Atlantique, Vannes, France. 202 Hôpital Jacques Monod, Le Havre, France. 203 Tergooi Hospital, Hilversum, Netherlands. 204 Michael Garron Hospital, Toronto, Canada.

Hospital de Curry Cabral - Infectious Diseases, Lisbon, Portugal. 205 Mount Sinai Medical Center, Miami, FL, USA.

Azienda Provinciale per i Servizi Sanitari della Provincia Autonoma di Trento, Arco, Italy. 206 Columbia University, New York, USA. 207 Centre Hospitalier Universitaire de Guadeloupe, Pointe-à-Pitre, Guadeloupe. 208 Ospedale Niguarda, Milan, Italy. 209 Centre hospitalier universitaire de Sherbrooke, Sherbrooke, Canada. 210 UW Cleveland Hospital, Cleveland, USA. 211 University Hospital - Waterford, Waterford, Ireland. 212 Saint Martin, Saint Martin, Guadeloupe. 213 Leiden University Medical Center, Leiden, Netherlands. 214 Centro Hospitalar de Tondela-Viseu, Viseu, Portugal. 215 St Christopher's Hospital for Children, Philadelphia, USA. 216 Piedmont Atlanta Hospital, Atlanta, Georgia, USA. 217 Hôpital Purpan, Toulouse, France. 218 Hôpital Saint-Louis AP-HP, Paris, France. 219 Centre hospitalier Emile Roux, Le Puy-en-Velay, France. 220 Hôpital Bel-Air, Thionville, France. 221 Centre Hospitalier Universitaire Toulouse (IUCT), Toulouse, France. 222 Airjine Hospital, Leiden, Netherlands. 223 Policlinico di Pavia, Pavia, Italy.

Centre hospitalier universitaire de Nîmes (Hôpital Archet), Nice, France. 224 Hôpital Albert Calmette, Lille, France.

Universität Ziekenhuis, Gent, Belgium. 225 INOVA Fairfax Medical Center, Fairfax, Virginia, USA. 226 Hospital Universitari Dr Negrín, Las Palmas, Spain. 227 Hospital Professor Doutor Fernando Fonseca, Amadora, Portugal.

Clinica Las Condes, Santiago, Chile. 228 Centre Hospitalier Medical Centre Groningen, Groningen, Netherlands. 229 Centre Hospitalier Mont-de-Marsan, Mont-de-Marsan, France. 230 Hôpital Rosemon, Cayenne, French Guiana. 231 Tallaght University Hospital, Dublin, Ireland. 232 Lions Gate Hospital, Vancouver, Canada. 233 Flevoziekenhuis, Almere, Netherlands. 234 St James's Hospital, Dublin, Ireland. 235 St Joseph's Health Center, Sherbrooke, Canada. 236 Centre hospitalier universitaire d'Angers, Angers, France. 237 Houston Methodist Hospital, Houston, Texas, USA. 238 Rochester General Hospital, New York, USA. 239 Oslo University Hospital, Oslo, Norway. 240 Cleveland Clinic, Ohio, Ohio, USA. 241 Medical College of Wisconsin, Wisconsin, USA. 242 Hôpital de la Conception, Marseille, France. 243 Centre hospitalier de Tourcoing, Tourcoing, France. 244 Reinier de Graaff Gasthuis, Delft, Netherlands. 245 Centre hospitalier universitaire Rennes (Hôpital Sud), Rennes, France. 246 Yokohama Medical and Pharmaceutical University, Sendai, Japan. 247 Mar del Plata Medical Foundation Private Community Hospital, Mar del Plata, Argentina. 248 Long COVID India - Terna Specialty Hospital and Research Centre, Mumbai, India. 249 Hôpitaux Puerta de Hierro, Jalisco, Mexico. 250 Canisius Wilhelmina Ziekenhuis, Nijmegen, Netherlands.

Hôpital Pellegrin, Bordeaux, France. 251 Centre hospitalier Pierre Oudot, Bourgoin-Jallieu, France. 252 North York General Hospital, Toronto, Canada. 253 Doctors Hospital, Lahore, Pakistan. 254 Adult ICU Saiful Anwar Hospital, Malang, Indonesia. 255 University of California San Francisco - Fresno, Fresno, USA. 256 Hospital Santa Maria, Centro Hospitalar Universitário Lisboa Norte, Amadora, Portugal. 257 Centre hospitalier Techer, Calais, France. 258 Centre hospitalier régional et universitaire de Tours, Tours, France. 259 University of Kansas Medical Center, Kansas, USA.

The Montreal Children's Hospital, Montreal, Canada. 260 Vancouver General Hospital, Vancouver, Canada. 261 Ospedale San Gerardo, Monza, Italy. 262 Hôpital Foch, Suresnes, France. 263 Bon Secours Hospital, Cork, Ireland. 264 Hospital Verge de la Cinta, Tortosa, Spain. 265 Hospital Escola da Universidade Federal de Pelotas, Pelotas, Brazil. 266 Saiseikai Senri Hospital, Tchigi, Japan. 267 Manipal Hospital Whitefield, Bangalore, India. 268 RSUP Fatmawati, South Jakarta, Indonesia. 269 Centre hospitalier de Pau, Pau, France. 270 Hôpital privé d'Antony, Antony, France.

Institut Universitaire de Cardiologie et de Pneumologie de Québec, Quebec City, Canada. 271 São João Hospital Centre, Porto, Portugal. 272 San Pedro de Alcantara Hospital, Cáceres, Spain. 273 Beth Israel Deaconess Medical Center, Boston, USA. 274 Ochsner Clinic Foundation, New Orleans, USA. 275 Medical College of Wisconsin, Milwaukee, WI, USA. 276 Lusgar State Medical University - Department of Internal Medicine No2, Lugansk, Ukraine. 277 Klinikum Passau, Germany. 278 Avera McKennan Hospital & University Health Center, Sioux Falls, South Dakota, USA.

Cleveland Clinic Abu Dhabi, Abu Dhabi, United Arab Emirates. 279 Columbia University, New York, USA. 280 University Hospital of Tubingen, Tubingen, Germany. 281 Permai Hospital, Johor, Malaysia. 282 University of Michigan Schools of Medicine & Public Health, Ann Arbor, USA. 283 Hospital Garcia de Orta, Almada, Portugal. 284 Wexford General Hospital, Wexford, Ireland. 285 Baylor Scott & White Health, Temple, USA. 286 Clinica Alemana De Santiago, Santiago, Chile. 287 Centre Hospitalier du Pays d'Aix, Aix-en-Provence, France. 288 Centre hospitalier universitaire Ambroise-Paré, Boulogne-Billancourt, France. 289 Grigore T Popa University of Medicine and Pharmacy, Bucharest, Romania. 290 Erasmus Medical Centre, Rotterdam, Netherlands. 291 Children's Hospital of Cleveland, University Medical Center Hamburg-Eppendorf, Hamburg, Germany. 292 Hospital de Curry Cabral - Internal Medicine, Lisbon, Portugal. 293 Azienda Ospedaliero Universitario Pisana, Pisa, Italy. 294 Centre hospitalier universitaire Toulouse (Larrey), Toulouse, France. 295 Hospital de Amor, Sao Paulo, Brazil. 296 Middlemore Hospital (Canties Manukan Health), Otahuhu, New Zealand. 297 Centre hospitalier de Soissons, Soissons, France. 298 UT Southwestern, Dallas, USA. 299 SIUT Hospital, Karachi, Pakistan. 300 Red Deer Regional Hospital, Red Deer, Canada. 301 Lady Reading hospital, Peshawar, Pakistan. 302 McLeod Healthcare System, Florence, USA. 303 Providence Saint John's Health Center, Santa Monica, USA. 304 Klung Hospital, Johor, Malaysia. 305 Kintampo Health Research Centre, Kintampo, Ghana. 306 University of Sri Lanka Medical Centre, Colombo, Sri Lanka. 307 Azaria Middelares, Gent, Belgium. 308 Dr. Jamal Hospital, Dammam, Saudi Arabia. 309 Universidad de Las Américas, Quito, Ecuador. 310 University of Maryland, Baltimore, USA. 311 Lancaster General Health, Pennsylvania, USA. 312 PICU Saiful Anwar Hospital, Malang, Indonesia. 313 Nagoya University Hospital, Nagoya, Japan. 314 Centre Hospitalier Le Mans, Le Mans, France. 315 Sultanah Bahiyah Hospital, Kedah, Malaysia. 316 Trucku Ja'afar,
Argentina. 315Hospital Charle. 316Nantes, France. 317Institut Pasteur, Gfres. 318University of Pittsburgh, Pittsburgh, PA, USA. 319University of Cape Town, Cape Town, South Africa. 320University of North Carolina at Chapel Hill, Chapel Hill, NC, USA. 321National Taiwan University Hospital, Taipei, Taiwan. 322European Medical School, Prif, Germany. 323University of Sheffield, Sheffield, UK. 324University of Arizona, Tucson, AZ, USA. 325Infectious Diseases Hospital, Athens, Greece. 326Hippokration Hospital, Thessaloniki, Greece. 327Hiroshima University, Hiroshima, Japan. 328Meine University Hospital, Tsu, Japan. 329Hospital Aleman, Buenos Aires, Argentina. 330Mills Memorial Hospital, Terrace, Canada. 331Raja Perempuan Zainab II Hospital, Kelantan, Malaysia. 332Catholic University, Quito, Ecuador. 333Hospital Nuestra Señora de Gracia, Zaragoza, Spain. 334Centre Hospitalier Universitaire Amiens-Picardie, Amiens, France. 335Sentara Norfolk General Hospital, Norfolk, USA. 336Kyung Poong National University Chilgok Hospital, Daegu, South Korea. 337Consortium IMGEM, Piaseczno, Poland. 338Tawau Hospital, Sabah, Malaysia. 339Melaka Hospital, Melaka, Malaysia. 340ABC Hospital, Visakhapatnam, India. 341Princess Margaret Hospital, Kwa. 342Singal General Hospital (Paediatric), Bali, Indonesia. 343National Children's Hospital, Columbus, USA. 344Shizuoka Children's Hospital, Shizuoka, Japan. 345Washington University in St. Louis, St Louis, Missouri, USA. 346University of Oklahoma Health Sciences Center, Oklahoma, USA. 347Groupe Hospitalier Diaconesses Croix Saint-Simon, Paris, France. 348Hospital for Tropical Diseases, Ho Chi Minh City, Vietnam. 349Unity Health Toronto, Toronto, Canada. 350Grande International Hospital, Kathmandu, Nepal. 351St. Joseph's Healthcare Hamilton, Hamilton, Canada. 352Lahat Datu Hospital, Sabah, Malaysia. 353University Hospital of North Norway, Tromso, Norway. 354Keimyung University Dong San Hospital, Daegu, South Korea. 355Kimitsu Chuo Hospital, Chiba, Japan. 356Hospital for Advanced Medicine and Surgery (HAMS) 1, Kathmandu, Nepal. 357Obihiro-Kosei General Hospital, Obihiro, Japan. 358St-Anna Ghstatu, Haarlem, Netherlands. 359Marmara University Hospital, Istanbul, Turkey. 360Kharkiv Regional Clinical Infectious Diseases Hospital, Kharkiv, Ukraine. 361University Health Network, Toronto, Canada. 362Apollo Hospitals Chennai, Chennai, India. 363Harford Healthcare, Hartford, USA. 364University Airline Hospital (Paediatric), Surabaya, Indonesia. 365Centre Hospitalier Alpes-Leman, Contamine-sur-Arve, France. 366Centre Hospitalier Universitaire Louple (Rouen), Toulouse, France. 367B & B Hospital, Lalitpur, Nepal. 368Pro Dr R. D. Kandou Central Hospital, Manado, Indonesia. 369National Hospital & Medical Center, Lahore, Pakistan. 370Centre Hospitalier Universitaire de Nîmes, France. 371Centre Hospitalier Universitaire de Poitiers, Poitiers, France. 372Queen Elizabeth Hospital, Sabah, Malaysia. 373Severance Hospital, Seoul, South Korea. 374Hôpital Henri-Mondor, Créteil, France. 375University of Applied Science and Respirology, Quebec, Canada. 376Sultanah Nur Zaharah Hospital, Terengganu, Malaysia. 377Centre Hospitalier Universitaire Gabriel Montpied, Clermont-Ferrand, France. 378Institute of TB and Lung Diseases, Warsaw, Poland. 379Watterson District Health Board, Auckland, New Zealand. 380Jinnah Hospital, Lahore, Pakistan. 381Angeles University Foundation Medical Center, Angeles, Philippines. 382Malawi-Liverpool Wellcome Trust, Lilongwe, Malawi. 383Saiseikai Utsunomiya Hospital, Tochigi, Japan. 384University of Florida, Gainesville, USA. 385Hospital de Clinicas, Buenos Aires, Argentina. 386Hospital Emergencia Ate Vitare, Lima, Peru. 387Port Macquarie Base Hospital, Port Macquarie, Australia. 388Netcare Unitas ECMO Centre, Centurion, South Africa. 389Hospital Universitario Virgen de Valme, Seville, Spain. 390Stanford University, Palo Alto, USA. 391Klinik und Poliklinik für Innere Medizin II, University Hospital Regensburg, Kiel, Germany. 392William Oster Health Sciences System - Etobicoke General Hospital, Toronto, Canada. 393Hôpital Louis-Mourier, Colombes, France. 394Mercy Hospital, Cork, Ireland. 395Hospital Vila Fx de xira, Lisbon, Portugal. 396La Paz Hospital, Madrid, Spain. 397Alberta Children's Hospital, Calgary, Canada. 398Centre Hospitalier de Colmar, Colmar, France. 399Kingston Health Sciences Centre, Kingston, Canada. 400Brooke Army Medical Centre, San Antonio, USA. 401International Islamic University Malaysia Medical Centre (IIUMMC), Pahang, Malaysia. 402Hospital Sirio-Libanes, Sao Paulo, Brazil. 403Waikato Hospital, Hamilton, New Zealand. 404Auckland City Hospital, Auckland, New Zealand. 405Mount Sinai Hospital, Toronto, Canada. 406London Health Sciences Centre, London, Canada. 407GMMC Teaching Hospital, Sukkur, Pakistan. 408Lahore General Hospital, Lahore, Pakistan. 409Centre Hospitalier de Cahors, Cahors, France. 410Borgo San Lorenzo Hospital, Trento, Italy. 411Centre Hospitalier Universitaire Rouen (Hôpital Charles Nicolle), Rouen, France. 412Hospital de Especiales Eugenio Espejo, Quito, Ecuador. 413Hospital Clinic, Barcelona, Spain. 414Tengku Ampuan Afzan Hospital, Pahang, Malaysia. 415Jinnah Post-Graduate Medical Center (SICU), Karachi, Pakistan. 416Saiin Health Systems, Toronto, Canada. 417BC Children's Hospital, Vancouver, Canada. 418Darul Sehat Hospital, Karachi, Pakistan. 419University Hospital Northern British Columbia, Prince George, Canada. 420St.-Pierre University Hospital, Brussels, Belgium. 421Hospital Do Aizo, Lisbon, Portugal. 422Queen Mary's Hospital, Pok Fu Lam, China. 423Queen Elizabeth Hospital, Yau Ma Tei, China. 424Siriraj Piyamaharajkarun Hospital (SIPH), Bangkok, Thailand. 425Oregon Health & Science University, Portland, USA. 426Department of Children's Infectious Diseases, Warsaw, Poland. 427Dr Sardjito Government Hospital, Yogyakarta, Indonesia. 428Alana Health, Oslo, Norway. 429Clinica Pasteur, Neuquén, Argentina. 430RUSD Pasar Minggu, South Jakarta, Indonesia. 431Misericordia Community Hospital, Edmonton, Canada. 432Legacy Emanuel Medical Center, Portland, USA. 433Instituto do Coração da Universidade de São Paulo (INCOR), São Paulo, Brazil. 434Joseph Brant Hospital, Burlington, Canada. 435Centres Medical Centre, Boston, USA. 436Mayo Clinic School of Medicine, Arizona, USA. 437Hospital General San Francisco, Quito, Ecuador. 438McMaster University, Hamilton, Canada. 439Azeema Sheikh Hospital, Islamabad, Pakistan. 440Hospital Beatriz Ângelo, Loures, Portugal. 441Niagara Health, Niagara, Canada. 442Isap General Hospital, Rourkela, India. 443Centre Hospitalier de Périgueux, Périgueux, France. 444University Hospital Ostrava, Ostrava-Poruba, Czechia. 445Humber River Hospital, Toronto, Canada. 446Maastricht University Medical Centre, Maastricht, Netherlands. 447University of Brescia, Brescia, Italy. 448North Estonia Medical Centre, Tallinn, Estonia. 449RSUD Dr. Soetomo, Surabaya, Indonesia. 450Pushpagiri Medical College Hospital, Kerala, India. 451Baylor University Medical Centre, Dallas, USA. 452National University Hospital, Singapore, Singapore. 453Bahria International Hospital, Islamabad, Pakistan. 454Hospital de Abrantes - ICU, Abrantes, Portugal. 455Hôpital Européen Marseille, Marseille, France. 456Centre Hospitalier Agen-Nérac, Agen, France. 457Patel Hospital, Karachi, Pakistan. 458University of Manitoba, Manitoba, Canada. 459The Center for Diagnosis, Santo Domingo, Dominican Republic. 460CHU Carémeau, Nimes, France. 461Mazankowski Heart Institute, Edmonton, Canada. 462Sheikh Zayed Medical
College Rahim yar Khan, Rahim yar Khan, Pakistan. 488 Hôpital Laennec - site de Quimper, Quimper, France. 489 Fundación Cardiovascular de Colombia, Florencia, Colombia. 490 Hospital Universitari Sant Joan D’Alacant, Alicante, Spain. 491 National Institute for Infectious Diseases Matei Bals, Bucharest, Romania. 492 Centro Hospitalar Universitário do Algarve, Portimão, Portugal. 493 RSPI Prof Dr Sulianti Saroso, Jakarta, Indonesia. 494 The Heart Hospital Baylor Plano, Plano, USA. 495 Gele Hospitals, Zutphen, Netherlands. 496 Krankenhaus Barmherzige Br, Regensburg, Germany. 497 Baylor AllSaints Medical Centre, Fort Worth, USA. 498 Sozialmedizinisches Zentrum Sud, Vienna, Austria. 499 Mehta Hospital, Chennai, India. 500 Centro Hospitalar de Leiria, Leiria, Portugal. 501 Tohoku University, Sendai, Japan. 502 Hyogo Prefectural Kakogawa Medical Center, Hyogo, Japan. 503 Tokyo Metropolitan Tama Medical Center, Tokyo, Japan. 504 St. Marianna University School of Medicine, Kawasaki, Japan. 505 Om Hospital, Kathmandu, Nepal. 506 Karuna Hospital, Kathmandu, Nepal. 507 Pamela Youde Nethersole Eastern Hospital, Chai Wan, China. 508 Grand River Hospital, Kitchener, Canada. 509 Seoul National University Bundang Hospital, Seoul, South Korea. 510 Hospital Naval Marcilio Dias, Rio De Janeiro, Brazil. 511 Hospital Universitário Clementino Fraga Filho, Rio de Janeiro, Brazil. 512 Baerum Sykehus, Gjøttem, Norway. 513 Sturgeon Community Hospital, St Albert, Canada. 514 University Hospital in Krakow, Krakow, Poland. 515 Centre Hospitalier Universitaire Grenoble-Alpes FU, Grenoble, France. 516 Hospital das Clinicas da Faculdade de Medicina da Universidade de Sao Paulo, Sao Paulo, Brazil. 517 Kyoto Medical Centre, Kyoto, Japan. 518 Yokohama City University Medical Center, Yokohama, Japan. 519 Fatmawati Hospital, Jakarta, Indonesia. 520 Complejo Hospitalario Dr Clementino Fraga, João Pessoa city, Brazil. 521 Nidan Hospital, Lalitpur, Nepal. 522 Centro Hospitalar Louis Raffali, Manosque, France. 523 University of Nebraska Medical Center, Omaha, USA. 524 Clínica Internacional, Lima, Peru. 525 Hôpital Robert-Debré AP-HP, Paris, France. 526 Dunedin Public Hospital, Dunedin, New Zealand. 527 Mater Dei Hospital, Belo Horizonte, Brazil. 528 ADRZ, Amsterdam, Netherlands. 529 Adrz, Goes, Netherlands. 530 Meander Medical Centre, Amersfoort, Netherlands. 531 Noordwest-Ziekenhuisgroep, Den Helder, Netherlands. 532 Kerala Institute of Medical Sciences, Trivandrum, India. 533 Grey Nun’s Community Hospital, Edmonton, Canada. 534 Beatrix ziekenhuis, Gorinchem, Netherlands. 535 Royal Columbian Hospital, Vancouver, Canada. 536 Kyoto Prefectural University of Medicine, Kyoto, Japan. 537 Kouritou Tousei Hospital, Seto City, Japan. 538 MedStar Washington Hospital Centre, Washington, USA. 539 Sultanah Aminah Hospital, Johor, Malaysia. 540 University of Western Australia/Fiona Stanley Hospital, Murdoch, Australia.