

# Large-scale ICU data sharing for global collaboration

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LETTER



# Large-scale ICU data sharing for global collaboration: the first 1633 critically ill COVID-19 patients in the Dutch Data Warehouse

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Dear Editor,

The coronavirus disease 2019 (COVID-19) pandemic continues to stretch intensive care unit (ICU) capacity to its limits worldwide and optimizing management of critically ill COVID-19 patients remains urgently needed [1]. Fortunately, most ICUs deploy Electronic Health Records (EHRs) to routinely capture high-frequency clinical information. These data reflect the clinical practice variation resulting from the novelty of COVID-19 as well as the variation in patient characteristics and outcomes between centers [2, 3]. Therefore, these data may be employed to better understand the clinical course of COVID-19 and individualize treatment.

Given these considerations, a large-scale ICU data sharing collaboration in The Netherlands was initiated for the COVID-19 pandemic, resulting in the Dutch Data Warehouse (DDW, Fig. 1). While the database is growing, at this point, the DDW combines pseudonymized EHR data from 23 intensive care units covering the entire ICU admission of all adult COVID-19 patients treated in these ICUs. Collected data include data from monitoring and life support devices, demographics, medication, fluid balance, comorbidities, laboratory results, and outcomes. All parameters were manually reviewed by intensive care

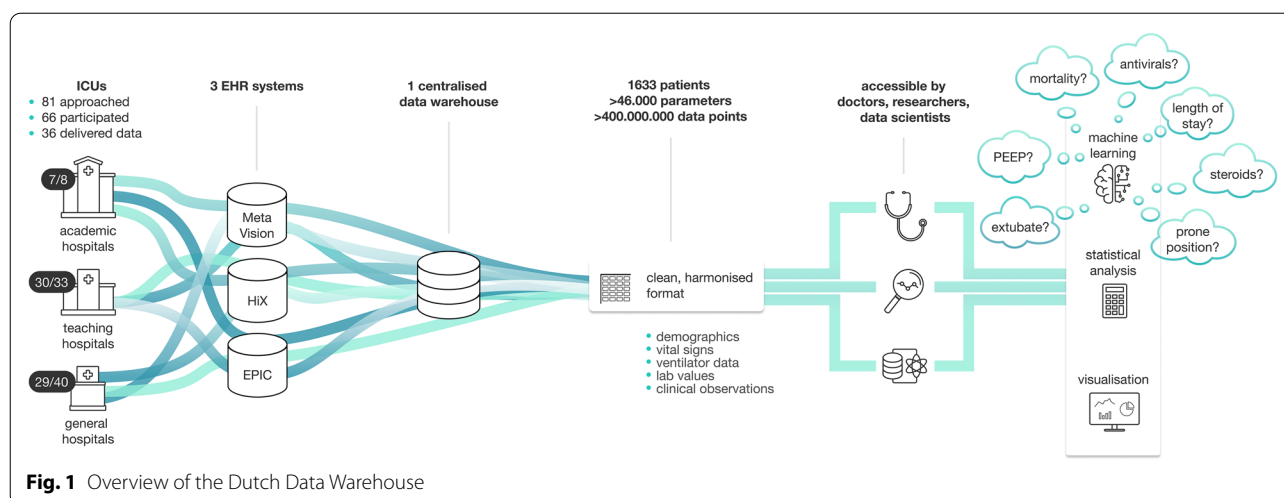
professionals and mapped to a common ontology. A software data pipeline converted units, filtered data entry errors, and calculated derived clinical parameters. Data validation was a continuous process including hospital data verification and visual inspection of distribution plots.

Detailed patient characteristics and technical information on the DDW are available in the online supplementary material (OSM). So far, 1633 patients treated between March and October 2020 have been processed and added to the DDW, now containing over 120 million data points mapped to a common ontology of 875 parameter names. Median age was 65 years (IQR 56–72) and 27.8% of patients were female. Mortality in the ICU was 25.4% overall, and 29.7% for mechanically ventilated patients. Hospital mortality was 33.1% and 36% for mechanically ventilated patients (available for 14/23 hospitals). Diabetes (22.9%), chronic obstructive pulmonary disease (COPD, 97%), and any immunodeficiency (9%) were the most common comorbidities. 78% of patients were intubated during their ICU stay, with 76.4% of these patients intubated within 10 hours after ICU admission. Patients were mechanically ventilated for a median of 12.4 days (IQR 6.4–22.6 days), with a reintubation rate of 13.4% among extubated patients. About half (53.9%) of patients were prone at least once and 72% of patients were prone within 48 h. The readmission rate was 4.7%. Preliminary analyses of respiratory characteristics in the first 24 h of invasive mechanical ventilation show a median *P/F* ratio of 164 mmHg (IQR 133–205). Respiratory system compliance after intubation was low 36 ml/cmH<sub>2</sub>O (IQR 29–45) with 30.8% of patients showing further drops by day 7. Initial positive end expiratory

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pressure (PEEP) was 14 cmH<sub>2</sub>O (IQR 10–15) and tidal volumes were 6.6 ml/kg (IQR 6.2–7.1). Thus, the general clinical picture and treatment is reminiscent of classic acute respiratory distress syndrome (ARDS).

The DDW is among the largest highly granular COVID-19 EHR datasets with full admission data to date. Coverage of entire ICU admissions can enable analyses known from general large ICU data sets such as MIMIC [4] and AmsterdamUMCdb [5]. In addition, the DDW paves the way for nationwide large-scale ICU data sharing beyond COVID-19. Importantly, given the ongoing pandemic, the intensive care and data science community are encouraged to utilize these data to optimize clinical care. Therefore, the DDW is available for global collaboration through <https://www.icudata.nl>.

#### Supplementary Information

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**References**

1. Bauer J, Brüggmann D, Klingelhöfer D et al (2020) Access to intensive care in 14 European countries: a spatial analysis of intensive care need and capacity in the light of COVID-19. *Intensive Care Med* 46:2026–2034
2. Wiersinga WJ, Rhodes A, Cheng AC et al (2020) Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. *JAMA* 324:782–793
3. Millar JE, Busse R, Fraser JF et al (2020) Apples and oranges: international comparisons of COVID-19 observational studies in ICUs. *Lancet Respir Med* 8:952–953
4. Thoral P, Elbers PWG (2020) Amsterdam Medical Data Science. <https://amsterdammedicaldatascience.nl/>. Accessed 25 Oct 2020
5. Johnson A, Bulgarelli L, Pollard T, Horng S, Celi LA, Mark R (2020) 'MIMIC-IV' (version 0.4). *PhysioNet*. <https://doi.org/10.13026/a3wn-hq05>