HAL
open science

Linking of global intensive care (LOGIC): An international benchmarking in critical care initiative

D.A. A Dongelmans, David Pilcher, Abigail Beane, Marcio Soares, Maria del Pilar Arias Lopez, Ariel Fernandez, Bertrand Guidet, Rashan Haniffa, Jorge I F Salluh

To cite this version:

D.A. A Dongelmans, David Pilcher, Abigail Beane, Marcio Soares, Maria del Pilar Arias Lopez, et al.. Linking of global intensive care (LOGIC): An international benchmarking in critical care initiative. Journal of Critical Care, 2020, 60, pp.305 - 310. 10.1016/j.jcrc.2020.08.031 . hal-03239782

HAL Id: hal-03239782

https://hal.sorbonne-universite.fr/hal-03239782v1

Submitted on 27 May 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Journal of Critical Care 60 (2020) 305–310

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

Linking of global intensive care (LOGIC): An international benchmarking in critical care initiative

D.A. Dongelmans [a,b,c,*], David Pilcher [c,d,e], Abigail Beane [c,f,g,h], Marcio Soares [c,i,j], Maria del Pilar Arias Lopez [c,k,l], Ariel Fernandez [c,k], Bertrand Guidet [c,l], Rashan Haniffa [c,f,g,h], Jorge I.F. Salluh [c,i,j]

[a] Amsterdam UMC, University of Amsterdam, Department of Intensive Care Medicine, Meibergdreef 9, Amsterdam, the Netherlands
[b] National Intensive Care Evaluation (NICE) foundation, Amsterdam, the Netherlands
[c] Department of Intensive Care, The Alfred Hospital, Commercial Road, Prahran VIC 3004, Australia
[d] The Australian and New Zealand Intensive Care Society (ANZICS) Centre for Outcome and Resource Evaluation, Camberwell VIC 3124, Australia
[e] Crit Care Asia, Network for Improving Critical Care Systems and Training, Colombo, Sri Lanka
[f] Mahidol Oxford Tropical Medicine Research Unit, Bangkok, Thailand
[g] Centre for Tropical Medicine and Global Health, University of Oxford, UK
[h] D'Or Institute for Research and Education, Rio de Janeiro, Brazil
[i] Post Graduation Program, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil
[j] Argentine Society of Intensive Care (SATI). SATI-Q Program, Buenos Aires, Argentina
[k] Hospital de Niños Ricardo Gutierrez, Buenos Aires, Argentina
[l] Sorbonne Université, INSERM, Institut Pierre Louis d'Epidémiologie et de Santé Publique, AP-HP, Hôpital Saint-Antoine, Service de réanimation, F75012 Paris, France

ARTICLE INFO

Keywords:
Critical care
Improvement science
Benchmarking
Global
Quality
Quality registry

ABSTRACT

Benchmarking is a common and effective method for measuring and analyzing ICU performance. With the existence of national registries, objective information can now be obtained to allow benchmarking of ICU care within and between countries. The present manuscript briefly describes the current status of benchmarking in healthcare and critical care and presents the LOGIC project, an initiative to promote international benchmarking for intensive care units. Currently 13 registries have joined LOGIC. We showed large differences in the utilization of ICU as well as resources and in outcomes. Despite the need for careful interpretation of differences due to variation in definitions and limited risk adjustment, LOGIC is a growing worldwide initiative that allows access to insightful epidemiologic data from ICUs in multiple databases and registries.

© 2020 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

1. Introduction

The complexity and costs of critical care delivery are a large burden on healthcare systems. Thus, it is crucial to understand the outcomes related to an intensive care admission [1]. This is not a simple task and involves several complex aspects including, but not limited to, definitions of crude outcomes, patient-reported or patient centered metrics, costs and adherence to evidence-based care measures [2,3]. Currently, intensivists and policy makers agree that measuring and tracking data and results of care provided in an Intensive Care Unit (ICU) is key to understanding its quality and identifying targets for improvement. "You can't improve if you don't measure." Since 1990, nearly all countries in the world have experienced an improvement in healthcare access and quality. Nonetheless huge discrepancies remain. A striking example is the fact that a young adult with a lower respiratory tract infection is over six times more likely to die in a low-income country than in a high-income country [4]. These data provide evidence that variation in care is a key factor to explain differences in outcomes. In intensive care, the ICON study showed that there were significant differences in the treatment of sepsis in the 84 participating countries and that outcomes also differed [5]. More recently the GBD sepsis data demonstrated that

although age-standardized sepsis incidence and mortality decreased from 1990 to 2017. Its incidence and mortality present substantial variation, with a clear increased burden low- and middle-income countries [6]. The ways healthcare systems are designed as well as the access to healthcare play a major role in these differences [7]. Implementation and adherence to protocols and processes of care may improve outcomes even in heterogeneous settings [8,9]. In the past 30 years, national intensive care registries have been created and became important in promoting performance assessment and quality improvement [10]. The availability of a rich source of data and periodic reporting of crude and risk-adjusted outcomes, as well as detailed case-mix evaluation, provide guidance and actionable information for

* Corresponding author at: D'Or Institute for Research and Education, Rua Diniz Cordeiro, 30 – 3° andar, Rio de Janeiro CEP 22281-100, Brazil.
E-mail address: d.a.dongelmans@amc.uva.nl (D.A. Dongelmans).

https://doi.org/10.1016/j.jcrc.2020.08.031
0883-9441/© 2020 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

implementation of research, evidence-based processes of care and data-driven management at ICUs locally and nationally. They have also become a paramount source for benchmarking in critical care.

Without objective data on the current situation and comparison with others' outcomes and best practices, healthcare organizations or nations cannot determine whether their efforts are acceptable, and specifically, what needs improvement. Benchmarking is a common and effective method for measuring and analyzing performance [11]. With the existence of national registries, objective information can now be obtained to allow benchmarking of ICU care between countries. The present manuscript briefly describes the current status of benchmarking in healthcare and critical care and presents the LOGIC project, an initiative to promote international benchmarking for intensive care units.

2. Benchmarking in healthcare

Benchmarking is a widely used term in various fields and usually applies to some form of comparison between products or services in order to ascertain a standard either with an internal or external target. One of the first accounts of the "competitive benchmarking" approach was reported at Xerox in 1992 [12]. To understand the current role of benchmarking in healthcare the statement of the Joint Commission is helpful: "Benchmarking is a systematic, data-driven process of continuous improvement that involves internally and/or externally comparing performance to identify, achieve, and sustain best practice. It requires measuring and evaluating data to establish a target performance level or benchmark to evaluate current performance and comparing these benchmarks or performance metrics with similar data compiled by other organizations, including best-practice facilities". In healthcare, large databases and registries are commonly used for benchmarking. The Agency for Healthcare Research and Quality's registries guide lists four major purposes for healthcare registries: 1) describing the natural history of the disease; 2) determining clinical effectiveness of treatments; 3) assessing safety or harm of treatments; and 4) measuring or improving quality of care. [13]. Ultimately the purpose is not only measurement but also improvement. How this works is described in a paper by Bevan et al. [14]. They explored the effect of reciprocal altruism with sanctions for unacceptably poor performance and rewards for high performance. These rewards and sanctions, are not monetary, but in the form of reputational effects through public reporting of benchmarking of performance. According to Bevan's theory, peer-group comparison develops the notion of necessity to improve.

3. The current and future role of global ICU registries in benchmarking

Several well-established initiatives have started ICU registries and enabled auditing of clinical data, thus allowing benchmarking. These include European registries such as ICNARC, NICE, CUB-réa, the Australian-New Zealand registry ANZICS CORE, and the pioneering ones in Latin America, SATIq and the Epimed Monitor database [15-19]. The role of such initiatives is to provide case-mix descriptions, resource utilization data, risk-adjusted outcomes as well as data on ICU-acquired complications and in some cases adherence to process of care indicators. These registries have a major role in quality improvement and also produce scientific publications on epidemiology, outcomes and health services utilization [9,20,21]. Therefore, they play an indisputable role in providing transparency on the utilization of critical care resources, as well as their related outcomes. This is key to allowing all stakeholders to use reliable and updated information for better clinical management and strategic decision-making. Despite publications on international comparisons of ICU epidemiology and outcomes [22,23]. scientific collaborations as well as the possibility to benchmark among countries are limited by several factors such as differences in definitions, distinct risk-adjustment methods, unavailability of data and complex harmonization of datasets in addition to legislative and professional restrictions and concerns about sharing information. In 2018, a group of leaders involved in several ICU registries from 4 different continents became interested in exploring the possibilities of a truly international

benchmarking platform which is called LOGIC (Linking of Global Intensive Care, www.icubenchmarking.com). The shared vision, which emerged during these explorative talks, was that it should be possible to create an inclusive and open organization allowing any registry or collaborative ICU database to join. The intention to combine registries from high, middle- and low-income countries is a unique opportunity for gaining insight and providing possibilities to understand differences in the approach for delivering and improving critical care worldwide. Aiming at becoming a point of connection for ICU databases and national registries, this independent initiative has its basis in promoting benchmarking and quality improvement for ICUs, discussing metrics and defining indicators amenable to comparison and providing an open-access international benchmarking platform. An important principle was the non-judgemental nature of participation. Contributors were well aware of large differences in healthcare delivery worldwide with significant variation in resource use, case mix and perhaps most importantly outcomes [25]. At the same time critical care physicians worldwide are keen to provide the best possible care within the constraints of their own healthcare systems.

4. The LOGIC project

After being officially launched with the participation of ANZICS-CORE (Australia and New Zealand), Epimed (Brazil, Belgium, Colombia, Uruguay), Critical Care Asia (CCA: Sri Lanka) and NICE (Netherlands), other registries promptly joined such as SATI-Q Programme (Argentina), *E*-Alberta critical care (Alberta region, Canada), CUB-Réa (public hospital ICUs in the Paris region) (see Table 1). A governance

structure was organized and a steering group was installed to formally make decisions for the global registry. Epimed (without financial compensation) provides a platform, gathers the data, does statistical analysis of the data and provides feedback of the data. This is arranged in such a way that participants of the contributing registries need to logon to their own websites' environment to be able to see the LOGIC data. The initial goal was the creation of a pragmatic but extensive overview of crude aggregated national data from registries. Some registries (for example Sri Lanka, NICE, ANZICS and Epimed) contributing to LOGIC already publicly report this aggregated data in annual reports, visualization portals or national publications. It was also necessary to avoid the need for row-by-row data leaving each registry. A decision not to use more granular data was mainly made to avoid regulatory and privacy issues. These issues could be barriers for subsequent registries to join and thus were avoided. The group was well aware that data quality and indicator definitions were another large issue, so these were discussed and agreed upon. An initial dataset of clinical characteristics to be displayed and benchmarked was defined.

Registries used their own definition as per registry standards and defined on their websites- for eg SNOMED, APACHE. Each registry has standards for validation and training LOGIC at this stage does not seek to adjudicate these diagnoses. Currently data from 2017 and 2018 are available at the benchmarking platform (Fig. 1). Data per registry includes: Number of patients, ICUs and hospitals, ICU and hospital crude mortality rates, length of stay, use of mechanical ventilation, renal replacement therapy and duration of mechanical ventilation. These variables are collected for all patients in the registry, however filters in the platform allow evaluation of the same variables for specific diagnosis or conditions such as sepsis, community-acquired pneumonia, CABG. An overview of aggregate data contained in the LOGIC benchmarking platform for 2018 is provided on Table 2. (See Fig. 2.)

Table 1
is showing the characteristics of the registries contributing to LOGIC. Including the total number of patients contributing to the registry until 2019.

ICU registry	Countries	ICUs (n)[a]	Admissions (n)[a]	Website
ANZICS-CORE	Australia and New Zealand	188	+2 million	www.anzics.com.au/core-portal/
Epimed Monitor	Brazil, Belgium, Uruguay, Colombia	+1.000	+2.5 millilion	Utisbrasileiras.com ucisuruguayas.com Micaproject.be uciscolombianas.com
NICE	Netherlands	85	+1 million	www.stichting-nice.nl/
Critical Care Asia[a]	Asia[a]	105	+65.000	https://www.tropmedres.ac/units/moru-bangkok/malaria/studies-study-sites/critical-illness
CUB-Réa	France (Paris Region)	53	+450.000	NA
SATIq	Argentina	83	+180.000	www.satiq.net.ar/

Patients in 2019 (total number of patients contributing to the registry until 2019).
[a] CCA includes 9 Asian countries (Afghanistan, Bangladesh, India, Malaysia, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam.)

5. Challenges

There are a number of challenges for LOGIC to truly succeed. Some of which are inherent to any benchmarking project and some of which come with the fact that an international benchmarking project needs to be aware of large contextual differences. Benchmarking in healthcare is only meaningful if it triggers improvement and thereby enhances the quality of care. In order to enable improvement, there are a number of prerequisites. Healthcare professionals must believe the feedback they receive and they must be able to make changes that influence the indicators chosen as a meaningful measure of quality. In other words, indicators must be of importance and must be actionable. Choosing and developing these indicators is the first challenge. Another challenge is case mix correction. If confronted with less favourable numbers, real or perceived differences in case mix are always a reason to question the feedback. In the current context LOGIC uses simple indicators such as number of IC beds, length of stay, mortality and demographics of patients. It is clear that case mix differences will have a huge impact on these indicators. The challenge is to define patient groups that are relatively easy to identify and to compare.

6. Examples of global initiatives that succeeded

There are several examples of global initiatives which successfully have overcome these challenges. Ignoring registries of relatively rare diseases such as retinoblastoma which contain relatively small number of patients [26], there are ample examples of successful global or multi country registries. For instance, the global registry on solid organ transplantation or the Era-Edta registry which, among other nefrologic conditions and therapies, provides feedback on renal replacement therapy [27]. The latter registry is an example of how to overcome the challenges described above. The Era-Edta registry is supported by national and international societies. Definitions, building coding systems, a clear organizational structure and perseverance during several decades has made this registry successful. The contextual challenges they overcame are exemplary. The differences in approach to kidney disease in

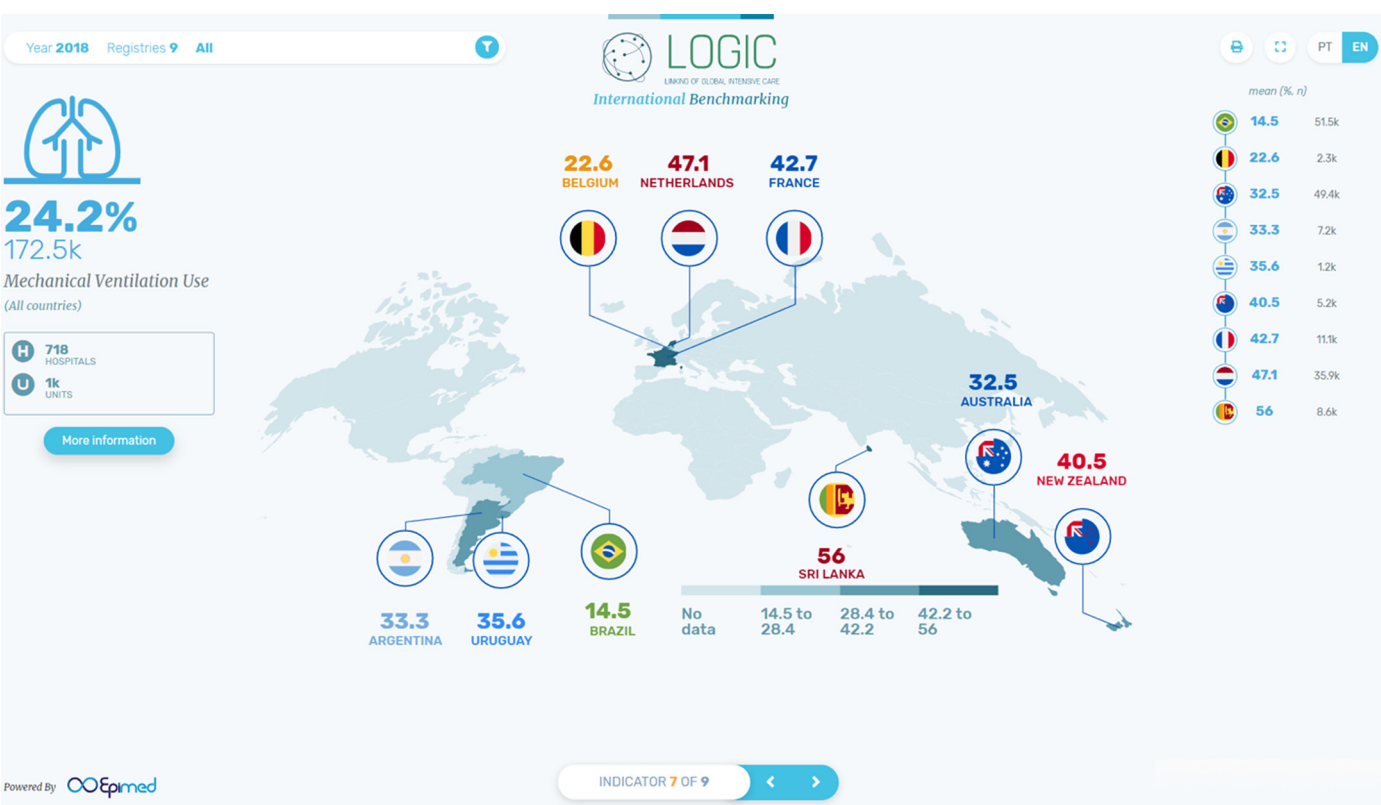

Fig. 1. Screenshot of the website of LOGIC. Displayed are percentages of mechanically ventilated patients per registry.

Table 2
Main patient's characteristics and outcomes in ICUs during year 2018.

Country	Argentina	Australia	Belgium	Brazil	France	Netherlands	New Zealand	CCA[a]	Uruguay
Patients (n)	21.600	152.200	10.900	377.100	26,000	76.300	12.800	32.800	3.500
Age	56,8	62,4	62,7	63,9	59	63,3	58,7	47,3	60
Mechanical ventilation (%)	33,3	32,5	22,6	14,5	42,7	47,1	40,5	56	35,6
ICU LOS	6,6	2,9	3,9	5,1	6	2,7	3,1	5,1	6,3
ICU mortality	18	4,7	10,4	10,7	12	9,5	7,2	14,6	18,8
Hospital mortality	–	7,4	15,1	16,3	17,2	12,7	10	–	21,7

[a] CCA includes 9 Asian countries (Afghanistan, Bangladesh, India, Malaysia, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam.)

different countries were of such a magnitude that this was a major challenge in the first years of this registry.

As we entered an internet and data dominated era we believe that LOGIC will not need decades to prove its role in enhancing quality of care in intensive care. Many hospitals make use of electronic health records worldwide provided by a limited number of vendors. Aligning those would, in the future, facilitate benchmarking.

Definitions used for the indicators currently available in the database need to be constantly re-evaluated and potentially normalized or adjusted. A way to introduce risk-adjusted outcomes is being evaluated, at least for hospital mortality, aiming to provide standardized mortality ratios, in addition to raw observed rates. Projects such as GOSSIS [28] and ORCHESTRA [29] are key to providing tools that can enable this. The Wellcome supports Crit Care Asia project which brings together nine Asian countries on a common registry platform will aid this endeavor as countries in the collaboration join the LOGIC collaboration. In this age of big data, we recognize that present lack of granularity limits the application of techniques such as machine learning. This does not, in our view, devalue the importance of simple comparisons of demographics and outcomes between registries or patient groups. At present moderated access through institutional and organizational accounts rather than full open public access to all information, has been the preferred approach. This is ensuring that differences in raw mortality rates can be interpreted by those with domain knowledge and an understanding of the limitations inherent in reporting data which does not account for case-mix variation and lacks 'risk-adjustment'.

The ability of the LOGIC platform to 'drill down' into specific patient populations such as 'sepsis' or 'community acquired pneumonia' allows some interpretation of the variation in outcomes while also potentially

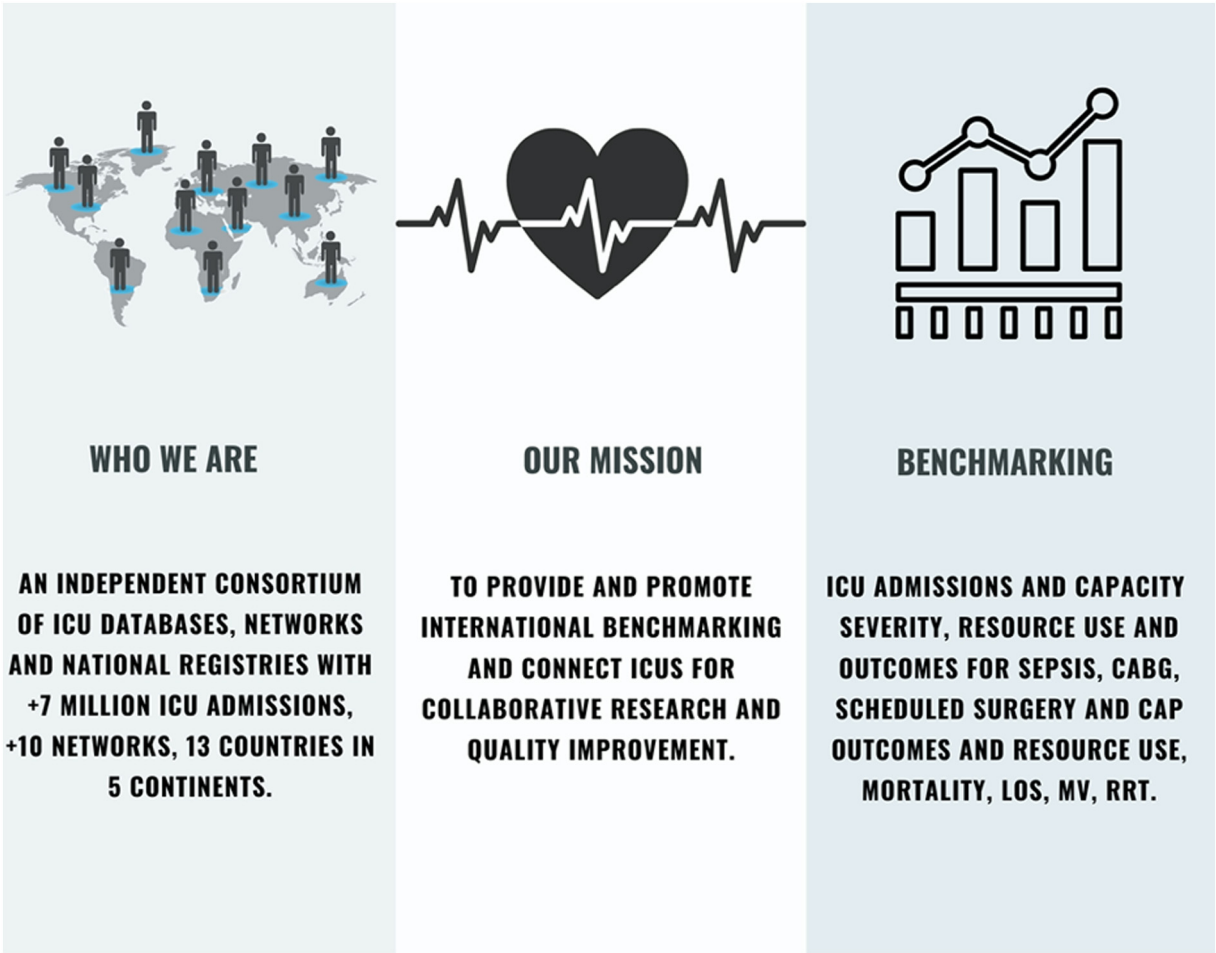

Fig. 2. Displaying basic information about the LOGIC initiative.

identifying groups where strategies to improve care may be targeted. Insight in other patient groups such as traumatic brain injury or postoperative patients is hopefully possible in the future. The future inclusion of more granular data will improve this by providing more in-depth case mix information and facilitate development of statistical risk adjustment models which will in turn lead to global benchmarking of a quality which has never been possible before. The use of common data models such as OMOP by the participating registries may enable pooled data analysis by investigators from within and outside the LOGIC collaboration without data having to physically leave the registries. With the LOGIC project, this is the first time global data from ICU registries has been shared with the purpose of benchmarking outside specific research projects. We strongly believe that being able to see oneself with others helps provide better care. In a recent study done in the Netherlands were benchmarking together with audit and feedback was used to improve pain management in Dutch ICU's it was shown that ICU's receiving feedback on the basis of their benchmark (top performers) improved

their practice. Enhancing this with a "toolbox" which contained suggestions on how to improve, led to even better results [30]. Feedback to potential outlier ICUs in Australia and New Zealand has been shown to be associated with improved outcomes and leads to significant financial savings to the health care sector [20].

7. Conclusions

Benchmarking may be used as a tool for quality improvement in critical care. We described the emergence of LOGIC, a global initiative for the benchmarking of critical care. Currently 13 registries have joined LOGIC. We showed large differences in the utilization of ICU as well as resources and in outcomes. Despite the need for careful interpretation of differences due to variation in definitions and limited risk adjustment, LOGIC is a growing worldwide initiative. Benchmarking in an inclusive way sheds light on international differences in the delivery of intensive care and will help future quality improvement initiatives in intensive care medicine.

Declaration of Competing Interest

Drs Salluh and Soares are co-founders and shareholders of Epimed Solutions, a cloud-based analytics company.

Acknowledgements

The authors wish to thank the technical staff at Epimed for their assistance with the preparation of the table and figures specially Andrea Watkins and Carolina Chiarello.

Financial support

Drs. Salluh and Soares are supported in part by individual research grants from CNPq and FAPERJ. Drs Beane and Haniffa are supported by a Wellcome trust grant (Crit Care Asia is supported by The Wellcome Trust).

References

[1] Geitona M, Androutsou L, Theodoratou D. Cost estimation of patients admitted to the intensive care unit: a case study of the teaching University Hospital of Thessaly. J Med Econ 2010. https://doi.org/10.3111/13696991003684092.

[2] Tan SS, Bakker J, Hoogendoorn ME, Kapila A, Martin J, Pezzi A, et al. Direct cost analysis of intensive care unit stay in four European countries: applying a standardized costing methodology. Value Health 2012. https://doi.org/10.1016/j.jval.2011.09.007.

[3] Hicks P, Huckson S, Fenney E, Leggett I, Pilcher D, Litton E. The financial cost of intensive care in Australia: a multicentre registry study. Med J Aust 2019;211:324–5. https://doi.org/10.5694/mja2.50309.

[4] cjlm@uw.edu GBD 2015 HA and QCE address:, Collaborators GBD 2015 HA and Q. Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990–2015: a novel analysis from the Global Burden of Disease Study 2015. Lancet (London, England) 2017; 390:231–66. https://doi.org/10.1016/S0140-6736(17)30818-8.

[5] Vincent JL, Marshall JC, Amendys-Silva SA, Francois B, Martin-Loeches I, Lipman J, et al. Assessment of the worldwide burden of critical illness: the Intensive Care Over Nations (ICON) audit. Lancet Respir Med 2014;2. https://doi.org/10.1016/S2213-2600(14)70061-X.

[6] Rudd KE, Johnson SC, Agesa KM, Shackelford KA, Tsoi D, Kievlan DR, et al. Global, regional, and national sepsis incidence and mortality, 1990–2017: analysis for the global burden of disease study. Lancet (London, England) 2020;395:200–11. https://doi.org/10.1016/S0140-6736(19)32989-7.

[7] Austin S, Murthy S, Wunsch H, Adhikari NKJ, Karir V, Rowan K, et al. Access to urban acute care services in high - vs. middle-income countries: an analysis of seven cities. Intensive Care Med 2014;40. https://doi.org/10.1007/s00134-013-3174-7.

[8] Machado FR, Ferreira EM, Schippers P, de Paula IC, Saes LSV, de Oliveira Jr FI, et al. Implementation of sepsis bundles in public hospitals in Brazil: a prospective study with heterogeneous results. Crit Care 2017;21:268. https://doi.org/10.1186/s13054-017-1858-z.

[9] Soares M, Bozza FA, Angus DC, Japiass AM, Viana WN, Costa R, et al. Organizational characteristics, outcomes, and resource use in 78 Brazilian intensive care units: the ORCHESTRA study. Intensive Care Med 2015. https://doi.org/10.1007/s00134-015-4076-7.

[10] Reper P, Dicker D, Damas P, Huyghens L, Haelterman M. Improving the quality of the intensive care follow-up of ventilated patients during a national registration program. Public Health 2017;148:159–66. https://doi.org/10.1016/j.puhe.2017.03.014.

[11] Wind A, van Harten WH. Benchmarking specialty hospitals, a scoping review on theory and practice. BMC Health Serv Res 2017;17:245.

[12] Walker R. Rank xerox—management revolution. Long Range Plann 1992;25:9–21.

[13] Gliklich R, Dreyer N, Leavy M. Registries for Evaluating Patient Outcomes: A User's Guide. . 3rd ed.Agency for Healthcare Research and Quality (US); 2014.

[14] Bevan G, Evans A, Nuti S. Reputations count: why benchmarking performance is improving health care across the world. Health Econ Policy Law 2019;14:141–61. https://doi.org/10.1017/S1744133117000561.

[15] Harrison DA, Brady AR, Rowan K. Case mix, outcome and length of stay for admissions to adult, general critical care units in England, Wales and Northern Ireland: the Intensive Care National Audit & Research Centre Case mix Programme Database. Crit Care 2004;8:R99–111. https://doi.org/10.1186/cc2834.

[16] van de Klundert N, Holman R, Dongelmans DA, de Keizer NF. Data Resource Profile: the Dutch National Intensive Care Evaluation (NICE) Registry of Admissions to Adult Intensive Care Units. Int J Epidemiol 2015;44(6). https://doi.org/10.1093/ije/dyv291 1850–1850h.

[17] McClean K, Mullany D, Huckson S, van Lint A, Chavan S, Hicks P, et al. Identification and assessment of potentially high-mortality intensive care units using the ANZICS centre for outcome and resource evaluation clinical registry. Crit Care Resusc 2017;19:230–8.

[18] Zampieri FG, Soares M, Borges LP, Salluh JIF, Ranzani OT. The Epimed monitor ICU database®: a cloud-based national registry for adult intensive care unit patients in Brazil TT - Epimed monitor ICU database®: um Registro nacional baseado na nuvem, Para pacientes adultos internados em unidades de terapia intensiv. Rev Bras Ter intensiva 2017;29:418–26. https://doi.org/10.5935/0103-507X.20170062.

[19] Editorial RevistaDe Argentina. Terapia Intensiva Programa SATI-Q: una experiencia local en Quality Benchmarking 2016;33(4).

[20] Straney LD, Udy AA, Burrell A, Bergmeir C, Huckson S, Cooper DJ, et al. Modelling risk-adjusted variation in length of stay among Australian and New Zealand ICUs. PLoS One 2017;12:e0176570. https://doi.org/10.1371/journal.pone.0176570.

[21] Salter R, Bailey M, Bellomo R, Eastwood G, Goodwin A, Nielsen N, et al. Changes in temperature management of cardiac arrest patients following publication of the target temperature management trial. Crit Care Med 2018;46:1722–30. https://doi.org/10.1097/CCM.0000000000003339.

[22] Ranzani OT, Shankar-Hari M, Harrison DA, Rabello LS, Salluh JIF, Rowan KM, et al. A comparison of mortality from Sepsis in Brazil and England: the impact of heterogeneity in general and Sepsis-specific patient characteristics. Crit Care Med 2019;47: 76–84. https://doi.org/10.1097/CCM.0000000000003438.

[23] Wunsch H, Angus DC, Harrison DA, Collange O, Fowler R, Hoste EAJ, et al. Variation in critical care services across North America and Western Europe. Crit Care Med 2008;36:2787–e9. https://doi.org/10.1097/CCM.0b013e318186aec8.

[24] Adhikari NKJ, Fowler RA, Bhagwanjee S, Rubenfeld GD. Critical care and the global burden of critical illness in adults. Lancet (London, England) 2010;376:1339–46. https://doi.org/10.1016/S0140-6736(10)60446-1.

[25] Tomar AS, Finger PT, Gallie B, et al. A multicenter, International collaborative study for ajcc-staging of retinoblastoma: treatment success and globe salvage [published online ahead of print, 2020 Jun 8]. Ophthalmology 2020;20:30524–8. https://doi.org/10.1016/j.ophtha.2020.05.051 S0161-6420.

[26] Berthoux F, Bernheim J, Gellert R, et al. The project of the European Renal Association (ERA-EDTA) for a European nephrological network. ERA registry and the ERA

council. Nephrol Dial Transplant 1998;13(Suppl. 1):30–3. https://doi.org/10.1093/ndt/13.suppl_1.30.

[27] Cosgriff CV, Celi LA, Ko S, Sundaresan T, de la Hoz MÁ Armengol, Kaufman AR, et al. Developing well-calibrated illness severity scores for decision support in the critically ill. Npj Digit Med 2019. https://doi.org/10.1038/s41746-019-0153-6.

[28] Moralez GM, Sarmet L, Rabello CF, Lisboa TC, Da M, Lima FA, et al. External validation of SAPS 3 and MPM 0 -III scores in 48,816 patients from 72 Brazilian ICUs. Ann Intensive Care 2017;753. https://doi.org/10.1186/s13613-017-0276-3.

[29] Roos-Blom M-J, Gude WT, de Jonge E, Spijkstra JJ, van der Veer SN, Peek N, et al. Impact of audit and feedback with action implementation toolbox on improving ICU pain management: cluster-randomised controlled trial. BMJ Qual Saf 2019;28:1007–15. https://doi.org/10.1136/bmjqs-2019-009588.