Clinical outcomes of Indigenous Australians and New Zealand Māori with metabolic acidosis and acidaemia

Ary Serpa Neto, Tomoko Fujii, James Moore, Paul J Young, Sandra Peake, Michael Bailey, Carol Hodgson, Alisa M Higgins, Emily J See, Paul Secombe, Vanessa Russ, Lewis Campbell, Meredith Young, Mikihiro Maeda, David Pilcher, Jamie Cooper and Andrew Udy

Globally, Indigenous people have higher rates of ill-health and dramatically shorter life expectancy than other groups living in the same countries.¹ The Aboriginal and Torres Strait Islander and the Māori people are recognised as the original inhabitants of Australia and Aotearoa New Zealand respectively. For these Indigenous peoples, the international findings of poorer health and lower life expectancy continue to be true.

Indigenous people comprise 3.3% of the Australian population and their lives differ in many important ways from the non-Indigenous population,² including access to health care delivered in an accessible manner.³⁻⁶ Despite known access barriers to health care, Indigenous people are still over-represented in intensive care unit (ICU) admissions and, in particular, have disproportionately higher rates of ICU admission due to sepsis and trauma. Further, admissions are more likely to be emergent, and the degree of physiological derangement at admission is greater, often with limited pre-morbid information despite membership of a high risk group.^{7,8} After adjustment for illness severity on ICU admission there is no difference in mortality between Indigenous and non-Indigenous people.⁷

Māori people comprise around 16% of the New Zealand population and have worse health outcomes than Pākehā people, with such inequities reflecting differences in health state, housing, education, employment, and social and economic deprivation.⁹ There are also differences in access to health care and in the quality of health care delivery for Māori compared with non-Māori people.⁹ Like Indigenous people, Māori people are less likely to be admitted to the ICU after elective surgery and proportionately more likely to be admitted to the ICU as an emergency.¹⁰ Sepsis and trauma are also common reasons for ICU admission for Māori people, and unlike Indigenous people, Māori people admitted to the ICU have higher mortality rates than their Pākehā counterparts.¹⁰

Decompensated metabolic acidosis is a major acid-base derangement in critically ill patients and may impair cardiac contractility, which may contribute to reduced

ABSTRACT

Objective: To assess the incidence and impact of metabolic acidosis in Indigenous and non-Indigenous patients.

Design: Retrospective study.

Setting: Adult intensive care units (ICUs) from Australia and New Zealand.

Participants: Patients aged 16 years or older admitted to an Australian or New Zealand ICU in one of 195 contributing ICUs between January 2019 and December 2020 who had metabolic acidosis, defined as pH < 7.30, base excess (BE) < -4 mEq/L and PaCO₂ ≤ 45 mmHg.

Main outcome measures: The primary outcome was the prevalence of metabolic acidosis. Secondary outcomes included ICU length of stay, hospital length of stay, receipt of renal replacement therapy (RRT), major adverse kidney events at 30 days (MAKE30), and hospital mortality.

Results: Overall, 248 563 patients underwent analysis, with 11 537 (4.6%) in the Indigenous group and 237 026 (95.4%) in the non-Indigenous group. The prevalence of metabolic acidosis was higher in Indigenous patients (9.3% v 6.1%; $P < 0.001$). Indigenous patients with metabolic acidosis received RRT more often (28.2% v 22.0%; $P < 0.001$), but hospital mortality was similar between the groups (25.8% in Indigenous v 25.8% in non-Indigenous; $P = 0.971$).

Conclusions: Critically ill Indigenous ICU patients are more likely to have a metabolic acidosis in the first 24 hours of their ICU admission, and more often received RRT during their ICU admission compared with non-Indigenous patients. However, hospital mortality was similar between the groups.

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oxygen delivery to tissues and induce insulin resistance. It is associated with increased mortality.¹¹⁻¹³ The incidence and prevalence of decompensated metabolic acidosis, and its consequences, in these cohorts of patients admitted to the ICU in Australia and New Zealand is unknown. However,

as sepsis and trauma are common causes of metabolic acidosis in the ICU, metabolic acidosis may be a particular problem among both Indigenous Australians and Māori New Zealanders (hereafter both respectfully referred to as Indigenous). We hypothesised that a greater proportion of Indigenous patients would present with a decompensated metabolic acidosis than non-Indigenous patients but that mortality outcomes would be equivalent.

The Australian and New Zealand Intensive Care Society (ANZICS) Adult Patient Database (APD) was used to identify all patients aged 16 years or older admitted to an Australian or New Zealand ICU in one of 195 contributing ICUs between January 2019 and December 2020 who had a decompensated metabolic acidosis, defined as a pH < 7.30, a base excess < -4 mEq/L and an arterial partial pressure of carbon dioxide (PaCO₂) ≤ 45 mmHg, as previously described.¹³ De-identified data were extracted by an independent investigator following the best practices described in the ANZICS-APD manual.

The primary outcome was the prevalence of decompensated metabolic acidosis in Indigenous compared with non-Indigenous patients using the definition for Indigenous specified in the ANZICS-APD data dictionary.⁶ Secondary outcomes included:

- ICU length of stay;
- hospital length of stay;
- receipt of renal replacement therapy;
- major adverse kidney events at 30 days (MAKE30, defined as death or receipt of renal replacement therapy within 30 days); and
- hospital mortality among patients with decompensated metabolic acidosis.

The study was approved by the Alfred Health Human Research Ethics Committee (424/21).

Continuous variables were reported as median and interquartile range (IQR) and compared with the Kruskal–Wallis test. Categorical variables are reported as number and percentage and compared with Fisher exact test. Due to the large sample size included, the significance level was set at 0.01 and hypothesis testing was performed only for outcomes. All analyses were performed using R v.4.0.2.

Overall, 248 563 patients underwent analysis, with 11 537 patients (4.6%) in the Indigenous group (7723 [3.1%] Indigenous and 3814 [1.5%] Māori) and 237 026 (95.4%) in the non-Indigenous group (Figure 1, A). The prevalence of decompensated metabolic acidosis was higher in Indigenous patients (9.3% v 6.1% [$P < 0.001$]; 9.4% in Indigenous v 9.2% in Māori v 6.1% in non-Indigenous [$P < 0.001$]) (Figure 1, B). This was still higher in Indigenous patients even after the exclusion of patients with chronic kidney disease at baseline (8.8% v 5.9% [$P < 0.001$]; 8.8% in Indigenous v 8.8% in Māori v 5.9% in non-Indigenous [$P < 0.001$]).

At baseline, Indigenous and Māori patients with decompensated metabolic acidosis were similar. They were younger, had higher Acute Physiology and Chronic Health Evaluation (APACHE) II scores, more often had cardiac arrest preceding ICU admission, received mechanical ventilation at day 1, and received inotropes or vasopressors (Table 1). Indigenous patients with decompensated metabolic acidosis received renal replacement therapy more often (28.2% v 22.0% [$P < 0.001$]; 28.2% in Indigenous v 29.0% Māori v 22.0% in non-Indigenous people [$P < 0.001$]) (Table 1 and Figure 1, C). After the exclusion of patients with chronic kidney disease at baseline, 23.2% of Indigenous compared with 20.5% of non-Indigenous patients ($P = 0.069$) received renal replacement therapy (21.2% in Indigenous v 27.7% Māori v 20.5% in non-Indigenous; $P = 0.024$). Pairwise

Table 1. Baseline characteristics and clinical outcomes of patients with metabolic acidosis

	Overall	Indigenous	New Zealand Māori	Non-Indigenous	<i>P</i>
Total number of patients	15 458	726	350	14 382	
Age, years, median (IQR)	65 (51–75)	51 (38–63)	55 (37–66)	66 (52–76)	< 0.001
Sex, male	8529 (55.2%)	374 (51.5%)	189 (54.0%)	7966 (55.4%)	0.106
APACHE III	76 (56–99)	78 (58–101)	81 (59–104)	75 (56–99)	0.014
ANZROD	10.2 (1.9–43.2)	11.6 (2.3–41.0)	14.9 (2.7–49.1)	10.0 (1.9–43.2)	0.081
Elective surgery	3175 (20.8%)	63 (8.7%)	35 (10.0%)	3077 (21.6%)	< 0.001
ICU source of admission					< 0.001
Operating room	5960 (38.6%)	162 (22.3%)	110 (31.4%)	5688 (39.6%)	
Emergency department	6075 (39.3%)	394 (54.3%)	173 (49.4%)	5508 (38.3%)	
Ward	2114 (13.7%)	81 (11.2%)	43 (12.3%)	1990 (13.8%)	

(Continues)

Table 1. Baseline characteristics and clinical outcomes of patients with metabolic acidosis (*continued*)

	Overall	Indigenous	New Zealand Māori	Non-Indigenous	P
Other ICU, same hospital	13 (0.1%)	0 (0.0%)	0 (0.0%)	13 (0.1%)	
Other hospital	983 (6.4%)	64 (8.8%)	16 (4.6%)	903 (6.3%)	
Other hospital ICU	297 (1.9%)	20 (2.8%)	8 (2.3%)	269 (1.9%)	
Direct ICU admission from home	15 (0.1%)	5 (0.7%)	0 (0.0%)	10 (0.1%)	
Cardiac arrest within 24 hours	1616 (10.6%)	81 (11.2%)	59 (17.0%)	1476 (10.4%)	0.001
Mechanical ventilation on day 1	8968 (60.7%)	458 (65.7%)	178 (59.9%)	8332 (60.4%)	0.019
Comorbidity					
Diabetes	4545 (36.9%)	328 (52.0%)	93 (38.8%)	4124 (36.0%)	< 0.001
Chronic respiratory failure	816 (5.3%)	47 (6.5%)	26 (7.4%)	743 (5.2%)	0.058
Chronic cardiovascular disease	1332 (8.6%)	80 (11.0%)	38 (10.9%)	1214 (8.4%)	0.018
Cirrhosis	407 (2.6%)	34 (4.7%)	3 (0.9%)	370 (2.6%)	< 0.001
Chronic kidney disease	1036 (6.7%)	116 (16.0%)	34 (9.7%)	886 (6.2%)	< 0.001
Organ support during ICU stay					
Inotropes and/or vasopressors	9657 (70.4%)	485 (73.4%)	216 (77.4%)	8956 (70.1%)	0.006
Mechanical ventilation	9204 (64.7%)	437 (65.6%)	194 (67.8%)	8573 (64.6%)	0.472
Laboratory tests on day 1, median (IQR)					
pH	7.25 (7.20–7.28)	7.24 (7.19–7.28)	7.24 (7.16–7.27)	7.26 (7.20–7.28)	< 0.001
Base excess, mEq/L	−11.2 (−15.2 to −8.5)	−12.1 (−16.5 to −9.1)	−12.1 (−17.4 to −8.8)	−11.1 (−15.0 to −8.4)	< 0.001
PaO ₂ :FiO ₂ ratio, mmHg	260 (164–368)	242 (154–367)	276 (180–380)	260 (164–367)	0.026
PaCO ₂ , mmHg	39 (33–42)	37 (31–42)	38 (32–42)	39 (34–42)	< 0.001
Lactate, mmol/L	3.0 (1.6–6.4)	3.0 (1.5–6.4)	4.3 (2.0–8.9)	3.0 (1.6–6.3)	< 0.001
Highest creatinine, µmol/L	143 (89–248)	165 (91–359)	170 (100–357)	141 (89–242)	< 0.001
Vital signs on day 1					
Lowest mean arterial pressure, mmHg	62 (56–68)	63 (56–68)	61 (54–67)	62 (56–68)	0.066
Highest heart rate, beats/min	106 (90–123)	110 (96–125)	110 (96–130)	106 (90–123)	< 0.001
Urine output, mL	1315 (622–2130)	1330 (475–2287)	1500 (474–2595)	1312 (630–2112)	0.223
Clinical outcomes					
ICU length of stay, days	2.7 (1.3–5.5)	3.3 (1.8–6.9)	1.9 (1.1–3.9)	2.7 (1.3–5.5)	< 0.001 ^{*,†,‡}
Hospital length of stay, days	9.2 (4.2–18.0)	9.5 (4.1–18.2)	6.7 (2.8–14.3)	9.3 (4.3–18.0)	< 0.001 ^{*,†,‡}
Receipt of RRT	2949 (22.4%)	184 (28.2%)	79 (29.0%)	2686 (22.0%)	< 0.001 ^{†,‡}
MAKE30	4952 (36.0%)	249 (36.8%)	135 (45.3%)	4568 (35.8%)	0.003 [‡]
Hospital mortality	3978 (25.8%)	175 (24.2%)	103 (29.4%)	3700 (25.8%)	0.181

ANZROD = Australian and New Zealand Risk of Death; APACHE = Acute Physiology and Chronic Health Evaluation; FiO₂ = fraction of inspired oxygen; ICU = intensive care unit; IQR = interquartile range; MAKE30 = major kidney adverse events on day 30; Paco₂ = arterial partial pressure of carbon dioxide; Pao₂ = arterial partial pressure of oxygen; RRT = renal replacement therapy. * P < 0.01 for the Indigenous versus Māori comparison. † P < 0.01 for the Indigenous versus non-Indigenous. ‡ P < 0.01 for Māori versus non-Indigenous.

Figure 1. Prevalence of Indigenous patients, decompensated metabolic acidosis, and use of renal replacement therapy (RRT) in Indigenous and non-Indigenous patients

A. Proportion of Indigenous and Māori among all critically ill patients admitted in the study period. The denominator used was the number of patients admitted to intensive care units (ICUs) in Australia (for Indigenous patients) or in New Zealand (for Māori patients). **B.** Proportion of patients with decompensated metabolic acidosis among all critically ill patients admitted in the study period. The denominator used was the number of patients admitted to ICUs in the study period. **C.** Proportion of patients receiving RRT among critically ill patients with decompensated metabolic acidosis. The denominator used was the number of patients with decompensated metabolic acidosis.

comparison according to each group is shown in Table 1. Hospital mortality was similar between the groups (24.2% in Indigenous v 29.4% Māori v 25.8% in non-Indigenous patients; $P = 0.181$).

We have shown that critically ill Indigenous and Māori patients are more likely to have a decompensated metabolic acidosis in the first 24 hours of their ICU admission and that, when compared with non-Indigenous patients, they more often received renal replacement therapy during their ICU admission. However, hospital mortality was similar between Indigenous and non-Indigenous patients. Our findings imply the need to conduct trials to effectively treat decompensated metabolic acidosis which disproportionately affect Indigenous Australians and Māori New Zealanders.

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Christchurch Hospital ICU, Coffs Harbour Health Campus ICU, Concord Hospital (Sydney) ICU, Dandenong Hospital ICU, Dubbo Base Hospital ICU, Dunedin Hospital ICU, Epworth Eastern Private Hospital ICU, Epworth Freemasons Hospital ICU, Epworth Geelong ICU, Epworth Hospital (Richmond) ICU, Fairfield Hospital ICU, Fiona Stanley Hospital ICU, Flinders Medical Centre ICU, Flinders Private Hospital ICU, Footscray Hospital ICU, Frankston Hospital ICU, Gold Coast Private Hospital ICU, Gold Coast University Hospital ICU, Gosford Hospital ICU, Gosford Private Hospital ICU, Goulburn Base Hospital ICU, Goulburn Valley Health ICU, Grafton Base Hospital ICU, Greenslopes Private Hospital ICU, Griffith Base Hospital ICU, Hawkes Bay Hospital ICU, Hervey Bay Hospital ICU, Hollywood Private Hospital ICU, Holmesglen Private Hospital ICU, Hornsby Ku-ring-gai Hospital ICU, Hurstville Private Hospital ICU, Hutt Hospital ICU, Ipswich Hospital ICU, John Fawkner Hospital ICU, John Flynn Private Hospital ICU, John Hunter Hospital ICU, Joondalup Health Campus ICU, Kareena Private Hospital ICU, Knox Private Hospital ICU, Latrobe Regional Hospital ICU, Launceston General Hospital ICU, Lingard Private Hospital ICU, Lismore Base Hospital ICU, Liverpool Hospital ICU, Logan Hospital ICU, Lyell McEwin Hospital ICU, Mackay Base Hospital ICU, Macquarie University Private Hospital ICU, Maitland Hospital ICU, Maitland Private Hospital ICU, Manning Rural Referral Hospital ICU, Maroondah Hospital ICU, Mater Adults Hospital (Brisbane) ICU, Mater Health Services North Queensland ICU, Mater Private Hospital (Brisbane) ICU, Mater Private Hospital (Sydney) ICU, Melbourne Private Hospital ICU, Middlemore Hospital ICU, Mildura Base Public Hospital ICU, Monash Medical Centre-Clayton Campus ICU, Mount Hospital ICU, Mount Isa Hospital ICU, Mulgrave Private Hospital ICU, National Capital Private Hospital ICU, Nelson Hospital ICU, Nepean Hospital ICU, Nepean Private Hospital ICU, Newcastle Private Hospital ICU, Noosa Hospital ICU, North Shore Hospital ICU, North Shore Private Hospital ICU, North

West Regional Hospital (Burnie) ICU, Northeast Health Wangaratta ICU, Northern Beaches Hospital ICU, Norwest Private Hospital ICU, Orange Base Hospital ICU, Peninsula Private Hospital ICU, Pindara Private Hospital ICU, Port Macquarie Base Hospital ICU, Prince of Wales Hospital (Sydney) ICU, Prince of Wales Private Hospital (Sydney) ICU, Princess Alexandra Hospital ICU, Queen Elizabeth II Jubilee Hospital ICU, Redcliffe Hospital ICU, Robina Hospital ICU, Rockhampton Hospital ICU, Rockingham General Hospital ICU, Rotorua Hospital ICU, Royal Adelaide Hospital ICU, Royal Brisbane and Women's Hospital ICU, Royal Darwin Hospital ICU, Royal Hobart Hospital ICU, Royal Melbourne Hospital ICU, Royal North Shore Hospital ICU, Royal Perth Hospital ICU, Royal Prince Alfred Hospital ICU, Ryde Hospital and Community Health Services ICU, Shoalhaven Hospital ICU, Sir Charles Gairdner Hospital ICU, South West Healthcare (Warrnambool) ICU, Southern Cross Hospital (Wellington) ICU, St Andrew's Hospital (Adelaide) ICU, St Andrew's Hospital Toowoomba ICU, St Andrew's Private Hospital (Ipswich) ICU, St Andrew's War Memorial Hospital ICU, St George Hospital (Sydney) ICU, St George Private Hospital (Sydney) ICU, St John of God (Berwick) ICU, St John Of God Health Care (Subiaco) ICU, St John Of God Hospital (Ballarat) ICU, St John of God Hospital (Bendigo) ICU, St John Of God Hospital (Geelong) ICU, St John Of God Hospital (Murdoch) ICU, St John of God Midland Public & Private ICU, St Vincent's Private Hospital Northside ICU, St Vincent's Hospital (Melbourne) ICU, St Vincent's Hospital (Sydney) ICU, St Vincent's Hospital (Toowoomba) ICU, St Vincent's Private Hospital (Sydney) ICU, St Vincent's Private Hospital Fitzroy ICU, Sunnybank Hospital ICU, Sunshine Coast University Hospital ICU, Sunshine Coast University Private Hospital ICU, Sunshine Hospital ICU, Sutherland Hospital & Community Health Services ICU, Sydney Adventist Hospital ICU, Sydney Southwest Private Hospital ICU, Tamworth Base Hospital ICU, Taranaki Health ICU, Tauranga Hospital ICU, The Bays Hospital ICU, The Chris O'Brien Lifehouse ICU, The Memorial Hospital (Adelaide) ICU, The Northern Hospital ICU, The Prince Charles Hospital ICU, The Queen Elizabeth (Adelaide) ICU, The Wesley Hospital ICU, Timaru Hospital ICU, Toowoomba Hospital ICU, Townsville University Hospital ICU, Tweed Heads District Hospital ICU, University Hospital Geelong ICU, Wagga Wagga Base Hospital & District Health ICU, Waikato Hospital ICU, Warrigal Private Hospital ICU, Wellington Hospital ICU, Werribee Mercy Hospital ICU, Western District Health Service (Hamilton) ICU, Western Hospital (SA) ICU, Westmead Hospital ICU, Westmead Private Hospital ICU, Whakatane Hospital ICU, Whangarei Area Hospital - Northland Health Ltd ICU, Wimmera Health Care Group (Horsham) ICU, Wollongong Hospital ICU, Wollongong Private Hospital ICU, Women's and Children's Hospital PICU, Wyong Hospital ICU.

Competing interests

All authors declare that they do not have any potential conflict of interest in relation to this manuscript.

Author details

Ary Serpa Neto^{1,2,3,4}
Tomoko Fujii^{1,5}

James Moore^{6,7}
Paul J Young^{1,2,6,7}
Sandra Peake^{1,8,9}
Michael Bailey¹
Carol Hodgson¹
Alisa M Higgins¹
Emily J See^{2,10}
Paul Secombe^{1,11,12,13}
Vanessa Russ¹⁴
Lewis Campbell^{12,15,16}
Meredith Young¹⁷
Mikihiro Maeda¹⁸
David Pilcher^{13,17}
Jamie Cooper^{1,17}
Andrew Udy^{1,17}

- 1 Australian and New Zealand Intensive Care Research Centre, School of Public Health and Preventive Medicine, Monash University, Melbourne, VIC, Australia.
- 2 Department of Critical Care, Melbourne Medical School, University of Melbourne, Austin Hospital, Melbourne, VIC, Australia.
- 3 Data Analytics Research and Evaluation Centre, Austin Hospital, Melbourne, VIC, Australia.
- 4 Department of Critical Care Medicine, Hospital Israelita Albert Einstein, São Paulo, Brazil.
- 5 Intensive Care Unit, Jikei University School of Medicine, Tokyo, Japan.
- 6 Intensive Care Unit, Wellington Hospital, Wellington, New Zealand.
- 7 Medical Research Institute of New Zealand, Wellington, New Zealand.
- 8 Department of Intensive Care Medicine, Queen Elizabeth Hospital, Adelaide, SA, Australia.
- 9 Faculty of Health and Medical Sciences, University of Adelaide, Adelaide, SA, Australia.
- 10 Department of Intensive Care Medicine, Austin Hospital, Melbourne, VIC, Australia.
- 11 Intensive Care Unit Alice Springs Hospital, Alice Springs, NT, Australia.
- 12 School of Medicine, Flinders University, Adelaide, SA, Australia.
- 13 Australian and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation, Melbourne, VIC, Australia.
- 14 Indigenous Data Network, University of Melbourne, Melbourne, VIC, Australia.
- 15 Intensive Care Unit, Royal Darwin Hospital, Darwin, NT, Australia.
- 16 Menzies School of Health Research, Darwin, NT, Australia.
- 17 Department of Intensive Care and Hyperbaric Medicine, Alfred Hospital, Melbourne, VIC, Australia.
- 18 Department of Pharmacy, St Marianna University School of Medicine Hospital, Kawasaki, Japan.

Correspondence: ary.serpaneto@monash.edu

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References

- 1 United Nations. State of the world's Indigenous peoples — Indigenous peoples' access to health services. UN, 2013. https://www.un.org/esa/socdev/unpfii/documents/2016/Docs-updates/SOWIP_Health.pdf (viewed Sept 2021).
- 2 Australian Bureau of Statistics. Estimates of Aboriginal and Torres Strait Islander Australians: summary commentary [Cat. No. 3238.0.55.001]. Canberra: Commonwealth of Australia, 2018. <https://www.abs.gov.au/ausstats/abs@.nsf/mf/3238.0.55.001> (viewed Sept 2021).
- 3 Australian Institute of Health and Welfare. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples: 2015 [Cat. No. IHW 42]. Canberra: AIHW, 2015. <https://www.aihw.gov.au/reports/indigenous-health-welfare/indigenous-health-welfare-2015/contents/table-of-contents> (viewed Sept 2021).
- 4 Lamb S, Huo S. Counting the costs of lost opportunity in Australian education. [Mitchell Institute Report No. 02/2017] Melbourne: Mitchell Institute, 2017. <https://www.vu.edu.au/sites/default/files/counting-the-costs-of-lost-opportunity-in-Aus-education-mitchell-institute.pdf> (viewed Sept 2021).
- 5 Australian Bureau of Statistics. 2016 Census shows growing Aboriginal and Torres Strait Islander population [media release]. Canberra: Commonwealth of Australia, 2017. <https://www.abs.gov.au/ausstats/abs@.nsf/MediaReleasesByCatalogue/02D-50FAA9987D6B7CA25814800087E03> (viewed Sept 2021).
- 6 Australian and New Zealand Intensive Care Society Centre for Outcomes and Resource Evaluation. APD data dictionary: ANZICS CORE — adult patient database; version 5.12. Melbourne: ANZICS CORE, 2017. <https://www.anzics.com.au/adult-patient-database-apd> (viewed Sept 2021).
- 7 Secombe P, Brown A, McAnulty G, Pilcher D. Aboriginal and Torres Strait Islander patients requiring critical care: characteristics, resource use, and outcomes. *Crit Care Resusc* 2019; 21: 200-11.
- 8 Hughes JT, Majoni SW, Barzi F, et al. Incident haemodialysis and outcomes in the Top End of Australia. *Aust Health Rev* 2020; 44: 234-40.
- 9 Reid P, Cormack D, Paine SJ. Colonial histories, racism and health — the experience of Māori and Indigenous peoples. *Public Health* 2019; 172: 119-24.
- 10 Slim MAM, Lala HM, Barnes N, Martynoga RA. Māori health outcomes in an intensive care unit in Aotearoa New Zealand. *Anaesth Intensive Care* 2021; doi: doi.org/10.1177/0310057X21989715.
- 11 Jung B, Rimmele T, Le Goff C, et al. Severe metabolic or mixed acidemia on intensive care unit admission: incidence, prognosis and administration of buffer therapy. A prospective, multiple-center study. *Crit Care* 2011; 15: R238.
- 12 Noritomi DT, Soriano FG, Kellum JA, et al. Metabolic acidosis in patients with severe sepsis and septic shock: a longitudinal quantitative study. *Crit Care Med* 2009; 37: 2733-9.
- 13 Mochizuki K, Fujii T, Paul E, et al. Early metabolic acidosis in critically ill patients: a binational multicentre study. *Crit Care Resusc* 2021; 23: 67-75.