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Original Article

How much do we throw away in the intensive care unit? An observational point prevalence study of Australian and New Zealand ICUs

Matthew H. Anstey, MBBS, FCICM, FACEM, MPH, AFRACMA ^{a, b, *}, Louise Trent, MBChB, FCICM, FANZCA, AFRACMA ^c, Deepak Bhonagiri, MBBS, MD, FCICM ^{d, e}, Naomi E. Hammond, RN, PhD ^{f, g}, Serena Knowles, RN, PhD ^g, Forbes McGain, FCICM FANZCA ^{h, i}, On behalf of The George Institute for Global Health and the Australian and New Zealand Intensive Care Society Clinical Trials Group^{bl}, Steering Committee members, Coordinating centre List of investigators, Site List of investigators

^a Intensive Care Department, Sir Charles Gairdner Hospital, Perth, Australia; ^b School of Medicine, University of Western Australia; ^c Intensive Care Unit, Te Matau a Maui Hawke's Bay, Te Whata Ora- Health, New Zealand; ^d Intensive Care Department, Campbelltown, Sydney, Australia; ^e Macquarie University, NSW, Australia; ^f Malcolm Fisher Department of Intensive Care, Royal North Shore Hospital, Sydney, Australia; ^g Critical Care Division, The George Institute for Global Health, Faculty of Medicine, UNSW Sydney, Sydney, Australia; ^h Western Health, Melbourne, Australia; ⁱ University of Melbourne, Australia

A B S T R A C T

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Objective: During the current COVID pandemic, waste generation has been more evident with increased use of single use masks, gowns and other personal protective equipment. We aimed to understand the scale of waste generation, recycling rates and participation in Australian and New Zealand (ANZ) ICUs. **Design:** This is a prospective cross-sectional point prevalence study, as part of the 2021 ANZICS Point Prevalence Program. Specific questions related to waste and sustainability practices were asked at the site and patient level.

Setting and participants: ANZ adult ICUs and their patients on the day of the study.

Main outcome measures: Amount of single use items disposed of per shift, as well as the engagement of the site with sustainability and recycling practices.

Results: In total, 712 patients (median number of patients per ICU = 17, IQR 11–30) from 51 ICUs across ANZ were included in our study; 55% of hospitals had a sustainability officer, and recycling paper (86%) and plastics (65%) were frequent, but metal recycling was limited (27%). Per patient bed space per 12-h shift there was recycling of less than 40% paper, glass, intravenous fluid bags, medication cups and metal instruments. A median of 10 gowns (IQR 3–19.5), 10 syringes (4.5–18) and gloves 30 (18–49) were disposed of per bed space, per 12-h shift. These numbers increased significantly when comparing patients with and without infection control precautions in place.

Conclusions: In ANZ ICUs, we found utilisation of common ICU consumables to be high and associated with low recycling rates. Interventions to abate resource utilisation and augment recycling are required to improve environmental sustainability in intensive care units.

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1. Introduction and background

We live in the Anthropocene, a time when humanity has an increasingly large environmental footprint that includes climate change, land and water pollution, biodiversity loss, and resource overconsumption.¹ In Australia, 7% of the nation's carbon emissions

* Corresponding author at: Intensive Care Department, Hospital Avenue, Sir Charles Gairdner Hospital, Perth 6009, Australia. Tel.: +61864571010.

E-mail address: Matthew.Anstey@health.wa.gov.au (M.H. Anstey).

^{bl} Group of collaborators are listed in Acknowledgement section

result from the healthcare system.^{2,3} There are nascent efforts to reduce healthcare's environmental footprint by advocacy groups,^{4–6} the Australian and New Zealand Intensive Care Society (ANZICS),⁷ and by governments at a systemic level (e.g. in the UK),⁸ and for healthcare to move to a more sustainable planetary health framework.⁹ Furthermore, the COVID pandemic has brought the amount of waste generated in healthcare settings to the fore, as exemplified by the millions of single use gowns, gloves and face masks used worldwide to protect healthcare workers and patients.^{10,11}

Per patient, the intensive care unit (ICU) consumes considerable amounts of hospital financial and physical resources,¹² energy¹³ and waste production. Prior Australian ICU waste audits have indicated that approximately 8 kg of mainly single-use equipment are discarded as waste per day.^{14,15} A single Australian ICU was able to recycle 15% of all ICU waste and about half of the potentially recyclable ICU waste.¹⁵ Beyond this single unit, it is unclear how much ICU recycling occurs. Further, despite recent moves by ANZICS to promulgate environmental sustainability in the ICU,⁷ current ICU sustainability activities are opaque.

We aimed to understand the scale of waste generated across Australia and New Zealand ICUs and to understand the current levels of recycling and participation in “greening hospital” movements to inform future efforts to improve the environmental sustainability of ICU practices. We included waste specific questions into the 2021 Australian and New Zealand Intensive Care Society Clinical Trials Group (ANZICS CTG) Point Prevalence Program (PPP).

2. Methods

We performed a prospective cross-sectional point prevalence study in Australian and New Zealand adult ICUs, as part of the Point Prevalence Program (PPP; a collaboration between the Australian and New Zealand Intensive Care Society Clinical Trials Group ANZICS CTG and The George Institute for Global Health), on 8 or 23 June, 2021. The authors consulted prior related studies^{13,15,16} for relevant questions about ICU waste and environmental sustainability queries.^{13,15,16} All sites had ethics approval with the majority of participating sites approved under one National Mutual Acceptance Low or Negligible Risk application approved by the lead ethics committee (Sydney Local Health District – Royal Prince Alfred Zone Ethics Committee; X18-0511 & HREC/18/RPAH/732).

In addition to the standard PPP patient demographic and admission data, specific questions relating to the amount of single use items disposed of in a single shift, patient requirement for personal protective equipment (PPE) and whether recycling of paper, glass vials, polyvinyl chloride (PVC) plastic intravenous fluid bags, metal instruments and medication cups occurred. In terms of the items disposed of, we did not distinguish between different types of gowns (such as plastic aprons or full-length PPE gowns), gloves (sterile or non-sterile) or masks (level of protection). Unit level questions included whether the ICU participates in recycling and whether the hospital has a sustainability officer and is a member of an environmental sustainability organisation such as the Global Green and Healthy Hospital network.⁶ Given that energy use in ICUs is a significant generator of carbon emissions,¹³ and heating and cooling is responsible for much of such energy use, we also asked about the ambient temperature in the ICU and whether it was able to be manipulated. The questions are provided in the Appendix. The research coordinators at each site entered the patient data via an online case report form using REDcap (Research Electronic Data Capture).¹⁷

Statistical analyses were performed using Stata 17 (StataCorp, Texas, USA). To standardise the number of items disposed of for each patient, as the nurses responding worked different shift lengths at different ICUs, the number of items was divided by the

shift length for the responding bedside nurse, and multiplied by 12, to give an approximation for a 12-h daytime shift. Categorical data were summarised using number (percentage), and proportions were compared using the Fisher exact test; continuous data were summarised as mean (standard deviation), or summarised as median (interquartile range [IQR]) and compared with Mann–Whitney (Wilcoxon rank sum) test.

3. Results

Data were available for 712 patients (median number of patients per ICU = 17, IQR 11–30) from 51 ICUs across Australia and New Zealand. Table 1 outlines the characteristics of the participating units and involvement in sustainability activities. Table 1 indicates the characteristics of the ICUs involved. Of the 51 ICUs involved, 49% were members of the Global Green and Healthy Hospitals (GGHH) Initiative, 55% had a hospital sustainability officer and 92% of the ICUs participated in recycling. Recycling paper (86%) and plastics (65%) were frequent, but metal recycling was limited (27%). Staff were unable to alter the temperature set point in 88% of ICUs.

Table 2 displays basic patient characteristics and common items used to care for them. Recycling from individual bed spaces was most common for paper (38%), then intravenous fluid bags (33%), glass (23%) and least for metals (4%), reflecting similar order, but less common frequency for recycling compared to Table 1.

Table 3 indicates differences in the use and quantity of common PPE for patients requiring infection prevention precautions. Importantly, the study did not distinguish between slight plastic aprons and robust, heavier gowns (such as those used for PPE).

4. Discussion

We undertook an observational point prevalence study of environmental sustainability activities in 51 ANZ ICUs, focused upon waste generation/recycling. Per 12-h shift, approximately 30 pairs of gloves, eight aprons/gowns and 10 syringes were used. Treatment of patients requiring infection prevention (1/4 total)

Table 1

Characteristics and sustainability initiatives in the participating Australian and New Zealand intensive care units.

	n = 51 (to nearest %)
CICM Level ICU - Level 1	1/51 (2%)
Level 2	16/51 (31%)
Level 3	34/51 (67%)
New Zealand	11/51 (22%)
Metropolitan	46/51 (90%)
Rural	5/51 (10%)
Public	45/51 (88%)
Private	6/51 (12%)
Hospital part of Global Green and Healthy Hospitals network	25/51 (49%)
Hospital has a sustainability officer	28/51 (55%)
Ambient temperature of unit (degrees Celsius)	22 °C (IQR: 21–22.5 °C)
Ability to alter the temperature of the unit (Y)	6/51 (12%)
ICU participates in recycling (Y)	47/51 (92%)
ICU recycles	
Soft plastics	33/51 (65%)
Hard plastics	33/51 (65%)
Paper	44/51 (86%)
PVC plastic	32/51 (63%)
Metal	14/51 (27%)

CICM Levels equate to the standards for Intensive Care Units (https://cicm.org.au/CICM_Media/CICMSite/CICM-Website/Resources/Professional%20Documents/IC-1-Minimum-Standards-for-Intensive-Care-Units_1.pdf) ranging from smaller (level 1) to level 3 - a tertiary level ICU.

Table 2
Characteristics of the patients, and the items used in their bed space on the day of the Point Prevalence Program survey.

	number
Age in years (mean, sd)	60.4 (16.9)
Gender (female)	264/712 (37%)
APACHE II (mean, sd)	16.9 (7.5)
Requirement for staff to wear PPE (Y)	166/712 (24%)
COVID suspected/positive	3/712 (0.4%)
Number of patients who had items recycled from their bed-space (in a single shift) (n, %)	
Paper	258/712 (38%)
Intravenous fluid bags	235/712 (33%)
Glass	154/712 (23%)
Medication cups	83/712 (12%)
Metal instruments	31/712 (4%)
Number of patients who had any items recycled from their bed space (n, %)	379/712 (53.2%)
Items disposed of, extrapolated to 12 h shift, per patient bed space (median, IQR)	
Aprons/Gowns	10 (3–19.5)
Masks of any sort	0 (0–3)
Syringes	10 (4.5–18)
Pairs of Gloves (non-sterile and sterile)	30 (18–49)

Abbreviations: PPE – personal protective equipment. IQR – interquartile range.

required 20 aprons/gowns, slightly greater numbers of gloves, but similar numbers of syringes. Approximately half of ICU patients had waste associated with their treatment recycled, and recycling rates varied considerably from 4% for metalware to 33% for PVC plastic. Despite these figures, half of the ICUs surveyed were members of the Global Green and Healthy Hospitals movement.

Our study was patient-centric, examining recycling rates at individual ICU bed-spaces. Units reported high rates of overall recycling, but this may reflect recycling items such as packing boxes, and does not estimate the penetration of recycling into daily clinical patient care practices. There was substantial variation between sites and bed spaces in the amount of waste generated. The waste generation and recycling rates of an ICU are nestled within the parent hospital, as well as the health system from within they work. For example, to increase recycling rates at the bed space would require designated recycling bins, and working with the waste provider for the hospital. Changing to recyclable items (such as paper medication cups) requires working with the procurement contracts for the hospital. These are solutions that have been infrequently implemented across Australia and New Zealand ICUs. This may be due to lack of awareness of successful case studies elsewhere, lack of space for adequate well labelled recycling bins, and lack of time in a busy ICU to consider recycling. Almost half of the participating ICUs were in hospitals supporting the Global Green and Healthy Hospitals (GGHH) Initiative, and also had sustainability officers. This suggests that there is willingness within these sites for improved environmental sustainability to occur, but that simply joining such initiatives is not, of itself, enough to lead to such change.

The association between higher waste generation in bed areas of patients with infection control precautions makes sense. However, it does highlight that perhaps these precautions can be carried too far and that strategies to reduce waste are necessary. For instance,

ward rounds could limit the number of people entering that bed-space, if they aren't adding extra clinical care to the patient. An analysis of the variability of infection control precautions across sites for the same condition (such as VRE or MRSA colonisation) would be helpful to understanding the benefits and harms of these precautions.

An adjacent issue leading to increased glove use is that the use of non-sterile gloves can create a false sense of protection. Nurses at London's Great Ormond Street hospital realised that healthcare professionals were choosing to use nonsurgical gloves instead of washing their hands, when performing tasks that did not have an infection precaution requirement, such as medication administration or moving beds. When nurses started to remind staff that the gloves weren't intended for these purposes, glove usage went down and the hospital was able to cut its use of plastic gloves, saving 21 tonnes of plastic and £90,000 (\$120,000) as a result.¹⁸

Previous published Australasian studies by McGain et al. in a single ICU reveal similar results.¹⁴ Our study was from a larger, heterogenous population and includes multiple ICU types (tertiary teaching, metropolitan and private ICUs). We could not locate similar studies from elsewhere. Data from the UK NHS includes whole of hospital data only.

Our study was conducted during the COVID-19 pandemic period and the low recycling rates seen in our results may have been affected by COVID-19 protocols for waste disposal. Nevertheless, the 2021 point prevalence program days missed the COVID-19 pandemic peaks, with less than 1% of ICU patients diagnosed with COVID-19. Thus, we cannot adequately comment upon waste generated from treating patients with COVID-19. Almost one fourth of our patients had non-COVID infection control precautions in place, showing that there are high rates of colonisation or contact with resistant organisms in our ICUs. Hu et al. reported on the rise in use of single use plastics during COVID-19, and their findings are relevant in our patient group.¹⁰ It is clear that some waste produced is considered hazardous (potentially infectious), but estimates suggest that this only accounts for about 15% of waste in hospitals, and the nonhazardous waste is where many of the reductions could occur.¹⁹ COVID-19 also illustrated that supply chain disruptions can cause problems when hospitals rely on single use disposable items in lieu of reusable equipment such as gowns.¹¹ Furthermore, when waste itself cannot be completely reduced, it is increasingly possible to look for other waste solutions, such as using biodegradable single use items (such as gowns, kidney dishes or medication cups).

Ambient temperature control forms the vast majority of the ICU's energy consumption.¹³ Reducing or increasing the set temperature by 0.5–1.0° is unlikely to have any significant effect on patients or staff but can reduce the energy consumption of ICUs significantly. Almost 90% of ICU staff surveyed were unable to alter the temperature of their own units, but perhaps they could collaborate with hospital engineers to undertake such changes.

Our prospective, observational study has limitations. The audit was performed over two calendar days, for a single 24-h period. Data were collected for each nursing shift, regardless of shift

Table 3
Items disposed of, comparing patients with and without the need for infection control precautions.

Numbers of items disposed of over 12 h shift	No precautions ^a (n = 525)	Infection prevention precautions ^a (n = 165)	P value
Aprons/gowns	7.5 (0–79.5)	19.5 (0–100)	0.000
Pairs of gloves	30 (0–198)	35 (0–208)	0.0065
Syringes	10 (0–112)	9 (0–90)	0.616
Masks	0 (0–24)	3 (0–49.5)	0.000

^a Median, IQR.

length (8–12 h), and we extrapolated all data out to 12 h. Unlike prior ICU studies,^{14,15} we did not quantify the mass of waste produced. We relied upon ICU staff completing the forms accurately and entirely. That is, there was no oversight of data collection accuracy nor did we obtain information about the proportion of staff who did/did not attempt the data forms. We did not distinguish between lightweight aprons and more robust, fully sleeved gowns, nor between different types of masks (N95 versus surgical). We also did not collect data on waste from food preparation. We did not ask about what are barriers to recycling at the bed space, and whether waste was being placed in the appropriate bin, as disposal of contaminated waste through incineration generates much a higher carbon footprint.^{20,21} Finally, we did not collect data on the barriers and enablers of recycling in the various units.

5. Conclusions

This point prevalence survey across 51 Australian and New Zealand ICUs the first step in describing the opportunities to improve the environmental sustainability of healthcare in Australian and New Zealand ICUs. The next is collaboration to improve our ICU sustainability practices.

Author contribution statement

MA: Conceptualization, Investigation, Methodology, Analysis, Writing-original. **LT/DB/FM:** Conceptualization, Methodology, Investigation, Writing-reviewing and editing. **SK/NH:** Investigation, Data curation, Methodology, Writing- Reviewing and Editing.

Conflicts of interest

Dr Anstey, McGain are members of the Doctors for the Environment Australia.

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PPP Day 13 list of participating sites and investigators

Steering Committee members

Naomi Hammond (Program Convenor), Serena Knowles (Program Manager), Amy Freeman-Sanderson, Subodh Ganu, Belinda Howe, Ed Litton, Diane Mackle, Manoj Saxena, Ian Seppelt, Miriam Towns, Elizabeth Yarad

Coordinating centre, List of investigators

The George Institute for Global Health, Sydney, NSW: Naomi Hammond, Serena Knowles, Annie Gao, Yang Li, John Myburgh, Ian Seppelt, Conrad Nangla, Fatima Butt

Site, List of investigators

Angliss Hospital (Eastern Health), Upper Ferntree Gully, VIC: Graeme Duke, Stephanie Hunter, Julie Evans, Dianne Parker, Clare Loughnan, Blessy Thomas; Auckland City Hospital, Cardiothoracic and Vascular Intensive Care Unit, Auckland, New Zealand: Eileen Gilder, Melissa Robertson, Ellie McMahon, Farisha Ali, Keri-Anne Cowdrey; Auckland City Hospital, Department of Critical Care Medicine, Auckland, New Zealand: Colin McArthur, Yan Chen, Catherine Simmonds, Rachael McConnochie, Caroline O'Connor; Ballarat Base Hospital, Ballarat, VIC: Khaled El-Khawas, Dianne Hill; Barwon Health, University Hospital Geelong, VIC: Claire Cattigan, Michelle Horton, Jemma Trickey; Bendigo Health, Bendigo, VIC: Cameron Knott, Julie Smith, Catherine Boschert; Blacktown & Mount Druitt Hospital, NSW: Treena Sara, Kiran Nand; Box Hill (Eastern Health), Melbourne, VIC: Graeme Duke, Stephanie Hunter, Julie Evans, Dianne Parker, Clare Loughnan, Blessy Thomas;

Caboolture Hospital, Caboolture, QLD: Mahesh Ramanan, Prashanti Marella, Julia Affleck; Cabrini Hospital, Melbourne, VIC: Shannon Simpson; Calvary Mater Newcastle, Newcastle, NSW: Katrina Ellem, Toni McKenna; Canberra Hospital, Garran, ACT: Mary Nourse, Kristine Leung, Tash Edmunds, Bree McDonald; Christchurch Hospital, Christchurch, New Zealand: Jan Mehrstens; Concord Hospital, Concord, NSW: Rosalba Cross, Helen Wong; Dunedin Hospital, Dunedin, New Zealand: Pawel Twardowski, Dawn France, Epworth Richmond, Melbourne, VIC: Gabrielle Hanlon, Jonathan Barrett; Fiona Stanley Hospital, Murdoch, WA: Annamaria Palermo, Susan Pellicano, Ege Eroglu; Flinders Medical Centre, Adelaide, SA: Shailish Bihari, Julia Brown, Laura Gear, Xia Jin; Footscray Hospital (Western Health), Melbourne, VIC: Craig French, Samantha Bates, Miriam Towns, Fiona Marshall, Rebecca McEldrew; Gold Coast University Hospital, Gold Coast, QLD: James McCullough, Mandy Tallott, Maimoonbe Gough; Goulburn Base Hospital, Goulburn, NSW: Marek Nalos, Laura Younger, Ravi Krishnamurphy; Hawkes Bay Fallen Soldiers Memorial Hospital, Hastings, New Zealand: Louise Trent, Janet How, Anne Stuart, Llesley Chadwick; Ipswich Hospital, Ipswich, QLD: Neeraj Bhadange, Steven Tyler; Logan Hospital, Logan, QLD: Kellie Sosnowski, Lynette Morrison, Joanne Sutton; Lyell McEwin Hospital, Elizabeth Vale, SA: Natalie Soar, David Lee; Maroondah Hospital, Ringwood East, VIC: Graeme Duke, Stephanie Hunter, Julie Evans, Dianne Parker, Clare Loughnan, Marina Doyle; Mater Hospital, Brisbane, QLD: Katherine Jongebloed, Mackenzie Finnis, Jane Wilson; Middlemore Hospital, Auckland, New Zealand: Tony Williams, Rima Song, Vivian Lai, Dinu Girijadevi, Hannah Habraken; Nelson Hospital, Nelson, New Zealand: Alex Browne, Jette Koelle, Charlotte McNab; Nepean Hospital, Penrith, NSW: Kristy Masters, Rebecca Gresham, Julie Lowrey, Christina Whitehead; North Shore Hospital, Auckland, New Zealand: Janet Liang; Princess Alexandra Hospital, Brisbane, QLD: Meg Harward, Cassie Jones; Queen Elizabeth Hospital, Woodville South, SA: Sandra Peake, Tricia Williams, Catherine Kurenda; Redcliffe Hospital, Redcliffe, QLD: Alexis Tabah, Maree Duroux, Timothy Warhurst, Megan Ratcliffe, Hamish Pollock, Stuart Baker; Rockingham General Hospital, Cooloongup, WA: Ravikiran Sonawane; Royal Adelaide Hospital, Adelaide, SA: Stephanie O'Connor, Nerissa Brown, Kathleen Glasby, Justine Rivett; Royal Darwin Hospital, Tiwi, Northern Territory: Lewis Campbell, Vera Tabuzo, Kirsty Smyth; Royal North Shore Hospital, Sydney, NSW: Elizabeth Yarad, Frances Bass, Naomi Hammond, Anne O'Connor; Royal Perth Hospital, Perth, WA: Anton Leonard, Sharon Waterson; Royal Prince Alfred Hospital, Sydney, NSW: Jennifer Coles, Heidi Buhr, Duncan Newman, Gayaporn Boorawong, Vanessa Bregolin, Ji-Hyun Yun; Sir Charles Gairdner Hospital, Nedlands, WA: Matthew Anstey, Lara Rock, Anthadene Endemann, Wei Lo; St John of God Hospital, Subiaco, WA: Janet Ferrier; St John of God Murdoch Hospital, Murdoch, WA: Annamaria Palermo; St Vincent's Hospital, Sydney, NSW: Claire Reynolds; St Vincent's Hospital Melbourne, Melbourne, VIC: John Santamaria, Jennifer Holmes; Starship Child Health, Auckland, New Zealand: John Beca, Claire Sherring; Sunshine Coast University Hospital, Birtinya, QLD: Peter Garrett, Lauren Murray, Jane Brailsford; Sunshine Hospital (Western Health), Melbourne, VIC: Craig French, Samantha Bates, Miriam Towns, Fiona Marshall, Rebecca McEldrew; Tauranga Hospital, Tauranga, New Zealand: Troy Browne, Jennifer Goodson; The Alfred, Melbourne, VIC: Andrew Udy, Meredith Young, Jasmin Board, Phoebe McCracken, Emma-Leah Martin; Waikato Hospital, Hamilton, New Zealand: Robert Martynoga, Amelia Butler, Kara Trask; Wellington Hospital, Wellington, New Zealand: Shaanti Olatunji, Rhoze Sol Cruz, Raulle Sol Cruz, Leanlove Navarra, Kirsha Delaney, Eden Lesona, Chelsea Young, Amelia Spring, April Aguilar, Paul Young, Erin Law

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