Australasian trends in intra-aortic balloon counterpulsation weaning: results of a postal survey

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ABSTRACT

Objective: To generate baseline data describing Australasian intra-aortic balloon counterpulsation (IABP) weaning practice.

Methods: A five-part questionnaire was mailed in April 2005 to all 192 intensive care units in Australia and New Zealand.

Results: 116 ICUs responded (response rate, 60%), and 54 reported using IABP. Most of the 54 were in hospitals which were public government-funded (65%), had between 100 and 500 beds (69%), and treated a minimum of 11 patients annually with IABP (60%). The most common method of withdrawing IABP support was ratio reduction alone (61%). ICUs most likely to undertake ratio weaning were higher-end users of IABP (> 20 cases per annum) ($P = 0.04$). Other weaning practices involved a combination of ratio followed by volume reduction (17%), volume then ratio (11%), and volume only (4%). Approaching statistical significance, ratio reduction weaning less frequently required IABP reinsertion or inotropic increase after balloon removal ($P = 0.07$). ICUs with documented weaning policies were less likely to require IABP reinsertion or inotropic increase after balloon removal ($P = 0.06$). Criteria considered important before IABP weaning or removal were: blood pressure (92%); heart rate (76%); pulmonary artery wedge pressure (59%); noradrenaline dose (78%); adrenaline dose (57%); and dobutamine dose (57%). Ninety per cent of ICUs reported increasing inotropes after balloon removal only rarely (1:50 patients) or occasionally (1:10 patients), while 87% of ICUs reported never needing to reinsert the balloon or only rarely.

Conclusion: The Australasian approach to IABP weaning is eclectic. While ratio reduction weaning appears the most successful manner of support withdrawal, it may be a consequence of a volume–outcome relationship, with high-end users achieving better results through IABP familiarity.

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Weaning intra-aortic balloon counterpulsation (IABP) is multifactorial. While weaning regularly incorporates mechanical ventilation, it principally integrates the withdrawal of mechanical support provided by the IABP drive console with a reduction in pharmacodynamic support provided by inotropic, vasopressor and vasoactive drugs. Opinion on the withdrawal of pharmacological support is consistent, suggesting that this support should be decreased before any reduction in IABP support.[1-5] However, attitudes to the withdrawal of mechanical support from the IABP drive console vary. The drive console offers the clinician two methods of weaning — reduction in either intra-aortic balloon volume or intra-aortic balloon ratio (ie, proportion of cardiac contractions which are assisted by the balloon). Research discusses current use of both methods, either alone or in conjunction, with each variation appearing successful.[1-4,6] The withdrawal of mechanical ventilation is equally problematic. A small number of publications discuss reducing IABP either before or after extubation,[2,7] as well as the potential benefit of positive end-expiratory pressure in reducing left ventricular preload and afterload.[8]

While the indications, complications and outcomes of IABP have been extensively studied,[9-15] there are few data on the optimum strategy for weaning IABP.[5] We undertook a study to generate baseline data on the current practice of IABP weaning in Australia and New Zealand, and the criteria and methods used in critically ill patients to assess whether IABP can be weaned and removed. The study set out to answer the following questions:

- What are the demographic and other characteristics of Australasian IABP?
- Which method, or combination of methods, do Australasian hospitals use to withdraw support in patients being treated with IABP?
- Which criteria are important for assessing whether IABP can be weaned and removed?

Methods

The study was a questionnaire-based survey of all 192 Australasian intensive care units. It was approved by the institutional ethics committees of the Prince Charles Hospital and The Queensland University of Technology, Brisbane, QLD.

The five-stem questionnaire informed hospital demographic characteristics, routine IABP monitoring, mechanical ventilation in association with IABP, IABP weaning, and balloon catheter removal. Each stem had differing

Table 1. Participating Australasian ICUs informing intra-aortic balloon counterpulsation weaning practice, by region*

Australian Capital Territory		
Calvary Hospital (Canberra)	John James Memorial Hospital	*The Canberra Hospital*
New South Wales		
Bathurst Base Hospital	Manly Hospital and Community Health Services	*St George Private Hospital*
Calvary Private Hospital (Wagga Wagga)	Manning River Base Hospital	*St Vincent's Hospital (Sydney)*
Canterbury Hospital	Mater Misericordiae Private Hospital (Sydney)	*St Vincent's Private Hospital (Sydney)*
Concord Repatriation Hospital	Newcastle Mater Misericordiae Hospital	*Strathfield Private Hospital*
Dalcross Private Hospital	*North Shore Private Hospital*	The Bankstown Lidcombe Hospital
Hornsby Ku-ring-gai Hospital & CHS	Orange Base Hospital	The Nepean Hospital
John Hunter Hospital	Port Macquarie Base Hospital	Wagga Wagga Base Hospital & DHS
Kempsey District Hospital	*Prince of Wales Hospital (Sydney)*	*Westmead Hospital*
Lismore Base Hospital	*Prince of Wales Private Hospital*	*Westmead Private Hospital*
Liverpool Hospital	*Royal North Shore Hospital*	Wollongong Hospital
Northern Territory		
Royal Darwin Hospital		
Queensland		
Allamanda Private Hospital	Mackay Base Hospital	Rockhampton Hospital
Brisbane Private Hospital	Mater Misericordiae Hospital (Brisbane)	Royal Brisbane Hospital
Caboolture Hospital	Mater Misericordiae Private Hospital (Brisbane)	*St Andrew's War Memorial Hospital*
Cairns Base Hospital	*Mater Misericordiae Private Hospital (Townsville)*	St Vincent's Hospital (Toowoomba)
Gladstone Hospital	Nambour General Hospital	*The Prince Charles Hospital*
Hervey Bay Hospital	*Princess Alexandra Hospital*	*The Wesley Hospital*
Ipswich Hospital	Redcliffe Hospital	*Townsville General Hospital*
Logan Hospital		
South Australia		
Calvary Hospital Adelaide	*Royal Adelaide Hospital*	The Queen Elizabeth Hospital
Flinders Private Hospital	St Andrew's Hospital (Adelaide)	*Wakefield Hospital*
Modbury Public Hospital	The Memorial Hospital (Adelaide)	Whyalla Hospital and Health Service
Tasmania		
Royal Hobart Hospital		
Victoria		
Austin Health	Frankston Hospital	*The Alfred Hospital*
Ballarat Health Services	Freemasons Hospital (Melbourne)	The Northern Hospital
Barwon Health — Geelong Hospital	Goulburn Valley Health	The Valley Private Hospital
Bendigo Health Care Group	Maroondah Hospital	Wangaratta District Base Hospital
Box Hill Hospital	Mildura Base Hospital	*Warringal Private Hospital*
Cabrini Hospital	*Monash Medical Centre — Clayton Campus*	Western District Health Service
Central Gippsland Health Service	Peter MacCallum Cancer Institute	Western Hospital
Dandenong Hospital	South West Healthcare — Warrnambool Campus	Wimmera Health Care Group
Epworth Hospital		
Western Australia		
Fremantle Hospital	*Royal Perth Hospital*	Saint John Of God Hospital Murdoch
Joondalup Health Campus	Saint John Of God Health Care Subiaco	*Sir Charles Gairdner Hospital*
New Zealand		
Auckland Hospital CVICU	North Shore Hospital	Timaru Hospital
Auckland Hospital DCCM	Nelson Hospital	Wairau Hospital
Christchurch Hospital	Palmerston North Hospital	*Wakefield Hospital*
Hawkes Bay Hospital	Rotorua Hospital	Wanganui Hospital
Health Waikato	*St Georges Hospital*	*Wellington Hospital*
Hutt Hospital	Tauranga Hospital	Whangarei Area Hospital, Northland Health

* Hospitals in italics have cardiac surgery facilities (as determined by > 100 adult cardiac surgical cases in 2004 identified in the IABP survey).

Table 2. Response rates to survey

Region	Total ICUs	Respondents
Australian Capital Territory	4	3 (75%)
New South Wales	60	30 (50%)
Northern Territory	2	1 (50%)
Queensland	35	22 (63%)
South Australia	17	10 (59%)
Tasmania	5	1 (20%)
Victoria	34	25 (74%)
Western Australia	9	6 (67%)
Australia	**166**	**98 (59%)**
New Zealand	**26**	**18 (69%)**
Australasia	**192**	**116 (60%)**

response sets which were narrow, direct and mutually exclusive to ensure accuracy of responses. All questions were closed-ended, with preset response options to reduce "no response" to individual items and yield a better completion rate.[16] The first question was: "Do you undertake IABP at your hospital?" If answered "No", then the participant was asked still to return the form as it would help generate demographic characteristics for Australasian IABP. The instrument was tested by staff in the General Intensive Care Unit at the Prince Charles Hospital for content validity, understanding, comprehension and completion time.

Respondent confidentiality was ensured through involvement of the Australian and New Zealand Intensive Care Society (ANZICS), which was responsible for mail out and return of surveys and held the key to institutional coding. No courtesy call was made to ICUs because of the number of institutions being surveyed.

Questionnaires were mailed to the medical director of each Level 1, 2 or 3 ICU throughout Australasia (166 in Australia and 26 in New Zealand). Every ICU was surveyed to avoid sampling bias or error and to obtain an accurate Australasian perspective. The survey asked for data based on activity at the hospital for the year 2004. The initial survey was sent in April 2005 and contained no return date. Five weeks later, a follow-up survey was mailed to Level 2 and 3 ICUs that had not responded, but not to Level 1 ICUs as it was considered unlikely (although not improbable) that they used IABP. The second survey set a 3-week return date, or the unit would be excluded from the study. Consent was implied with return of the survey form. Participation was entirely voluntary, with participants free to withdraw at any stage.

Summary, non-parametric and χ^2 statistical tests were performed with SPSS version 12 (SPSS Inc, Chicago, Ill, USA).

Table 3. Characteristics of intensive care units informing intra-aortic balloon counterpulsation (IABP) practice (*n* = 54)

Hospital characteristic	No. (%)
Public	35 (65%)
Private	19 (35%)
Cardiac tertiary referral	11 (17%)
University affiliated	12 (22%)
Number of beds	
< 100	1 (2%)
100–500	37 (69%)
501–800	14 (26%)
> 800	1 (2%)
Cardiac surgery cases annually	
< 100	14 (25%)
101–500	30 (56%)
501–999	7 (13%)
> 1000	3 (6%)
Number of patients treated with IABP annually*	
< 10	20 (37%)
11–20	10 (19%)
21–49	12 (22%)
> 50	10 (19%)

* Two units identified IABP use but did not specify the number of patients treated with IABP in 2004.

Results

What are the demographic and other characteristics of Australasian IABP?

One hundred and sixteen ICUs returned completed survey forms (response rate, 60% overall, and 70% for Level 2 and 3 ICUs). Responses were received from all Australian states and territories, as well as New Zealand's North and South Islands (Table 1). The New Zealand response rate (69%) was marginally higher than that of Australia (59%) (Table 2). While all 116 responding ICUs contributed to inform the scale of IABP throughout Australasia, only 54 ICUs used IABP in 2004. These 54 were used to generate Australasian IABP practice data and demographic characteristics.

Of the 54 ICUs that used IABP, 65% were in public hospitals and 35% in private hospitals, 17% were cardiac tertiary referral centres, and 22% were affiliated with universities (Table 3). Most had between 100 and 500 beds (69%), while 26% had between 501 and 800 beds, and only 4% had either less than 100 beds or more than 800 beds (Table 3). Sixty three percent of ICUs treated 11 or more patients with IABP per annum (11–20, 19%; 21–49, 22%; 50 or more, 19%), and 37% of ICUs treated fewer

Table 4. Predominant indications for intra-aortic balloon counterpulsation (IABP) in 54 Australasian intensive care units

IABP indication	No. (%)*
Cardiogenic shock	48 (89%)
Weaning from cardiopulmonary bypass	35 (65%)
Before coronary bypass in high-risk patients	20 (37%)
Support and stabilisation for coronary angiography	18 (33%)
Mechanical complications due to AMI	18 (33%)
Unstable refractory angina	10 (19%)
Refractory ventricular failure	10 (19%)
Ischaemia related to intractable ventricular arrhythmias	1 (2%)
Intraoperative pulsatile flow generation	1 (2%)

AMI = acute myocardial infarction.
* Figures reflect the number of ICUs recognising the indication as one of the three main IABP applications in their centre.

than 10 patients per annum with IABP (Table 3). More than half the units (56%) managed between 101 and 500 cardiac surgery patients per annum, while 25% managed fewer than 100 (which includes the possibility of no cardiac surgery patients), 13% managed between 501 and 999, and 6% managed in excess of 1000 cases.

The predominant Australasian indication for IABP was cardiogenic shock, nominated as one of the three main IABP indications in their centre by 89% of ICUs (Table 4). Other indications were weaning from cardiopulmonary bypass (nominated as among the top three indications by 65%), preoperative use in high-risk coronary bypass patients (37%), support and stabilisation for coronary angiography (33%), mechanical complications due to acute myocardial infarction (33%), unstable refractory angina (19%), refractory ventricular failure (19%), ischaemia related to intractable ventricular arrhythmias (2%) and intraoperative pulsatile flow generation (2%). Interventions used routinely in conjunction with IABP were central venous catheter (87%), intra-arterial line (72%), pulmonary artery catheter (70%), transthoracic echocardiography (41%), transoesophageal echocardiography (39%), continuous cardiac output monitoring (7%), and saturated venous oxygenation (2%).

In most (70%) Australasian ICUs, balloon catheters were removed only during the day (06:00 to 18:00). However, 20% of ICUs were prepared to remove the catheter at any time of day, while 8% removed the catheter only between 08:00 and 12:00 (2% did not reply to this question). Following removal of IABP, 33% of ICUs rarely increased inotropes (in 1:50 patients), 57% increased these occasionally (1:10 patients), 4% frequently (1:4 patients), and one unit increased inotropes in more than one in every four patients (one ICU did not reply to this question). Seventeen percent of ICUs never need to reinsert the intra-aortic balloon, while 70% rarely, and 9% occasionally reinserted the balloon (4% did not reply to this question).

Which method, or combination of methods, do Australasian hospitals use to withdraw support in patients being treated with IABP?

The most common method used to withdraw IABP support was ratio reduction alone (61%). A combination of ratio reduction followed by volume reduction was used by 17% of ICUs, and the reverse — volume reduction followed by ratio reduction — in 11%, with volume reduction alone used by 4% (Table 5). Approaching statistical significance, ratio weaning alone appeared more likely than any variation of volume weaning (volume alone, volume then ratio, or ratio then volume) to less frequently require IABP reinsertion or inotropic increase after balloon removal ($P = 0.07$). ICUs most likely to undertake ratio-alone weaning were more frequent users of IABP, using 20 or more balloons annually ($P = 0.04$).

In patients treated with IABP who are mechanically ventilated and pharmacologically dependent, three treatment modalities may be withdrawn: IABP support; ventilation; and pharmacological support. The clinical improvement of the patient's condition determined treatment withdrawal as follows: no usual order (39%); IABP, followed by ventilation, and then pharmacological support

Table 5. Weaning intra-aortic balloon counterpulsation (IABP) and sequential reduction of cardiac support in patients treated with IABP ($n = 54$)

Management	No. (%)
Method of IABP weaning	
Ratio reduction alone	33 (61%)
Ratio reduction followed by volume reduction	9 (17%)
Volume reduction followed by ratio reduction	6 (11%)
Volume reduction alone	4 (4%)
No answer	2 (7%)
Sequence of support withdrawal	
No usual order	21 (39%)
IABP, ventilation, then pharmacological	12 (22%)
Pharmacological, IABP, then ventilation	11 (20%)
IABP, pharmacological, then ventilation	3 (5%)
Ventilation, IABP, then pharmacological	2 (4%)
Pharmacological, ventilation, then IABP	2 (4%)
Ventilation, pharmacological, then IABP	1(2%)
No answer	2 (4%)

(22%); pharmacological support, IABP, and then ventilation (20%); IABP, pharmacological support, and then ventilation (5%); ventilation, IABP, and then pharmacological support (4%); pharmacological support, ventilation, then IABP (4%); ventilation, pharmacological support, then IABP (2%) (4% no response) (Table 5). In the presence of IABP, 9% of ICUs ventilated patients always, 67% mostly, and 24% sometimes. No ICU chose exclusively never to ventilate a patient undergoing IABP treatment. Positive end-expiratory pressure was specifically increased for IABP in only one Australasian ICU (an increase to 10 cmH_2O was observed).

IABP weaning was conducted by either medical staff alone (69%) or a combination of medical and nursing staff (29%) (2% no response). A quarter (26%) of ICUs had a written policy for IABP weaning (9% of these ICUs undertook multidisciplinary IABP weaning). Patient outcome following IABP removal was improved in the presence of a weaning policy. Regardless of the weaning strategy, ICUs with a documented policy were most likely to demonstrate a favourable outcome after IABP removal ($P = 0.06$). Twenty per cent of ICUs required that documented criteria be met before balloon removal (6% of these ICUs undertook multidisciplinary IABP weaning).

Which criteria are important for assessing whether IABP can be weaned and removed?

In most circumstances, commencement of either IABP weaning or balloon removal depended on the patient exhibiting features indicating that treatment withdrawal was likely to be successful. Of the 54 ICUs informing practice, 46 specified criteria they considered of importance. Eight did not stipulate criteria but stated that they were based on individual patient assessment and consequently might vary between patients. Ninety-two per cent of the ICUs that specified criteria applied the same criteria before both IABP weaning and removal. However, 4% of ICUs that stipulated different criteria for IABP weaning and IABP removal expected that pharmacological requirements would be reduced before IABP removal. The other 4% expected that both pulmonary artery wedge pressure and

Table 6. Physiological criteria considered important before intra-aortic balloon counterpulsation (IABP) weaning and removal by 46 intensive care units that used specified criteria*

	Number of ICUs (%)				
Criterion	Important	Not important	No response	Not used	Response range
Blood pressure	42 (92%)	2 (4%)	2 (4%)	0	MAP > 60 mmHg; systolic > 100 mmHg
Heart rate	35 (76%)	8 (17%)	7 (3%)	0	> 40 beats/minute; < 120 beats/minute
Pulmonary artery wedge pressure	27 (59%)	18 (39%)	1 (2%)	0	> 5 mmHg; < 22 m^2
Heart rhythm	23 (50%)	21 (46%)	2 (4%)	0	Sinus rhythm; atrial fibrillation; paced
Gas exchange	19 (41%)	23 (50%)	5 (9%)	0	< 50% FIO_2; PaO_2 > 60 mmHg; pulmonary function > 200
Haemoglobin	18 (39%)	26 (57%)	2 (4%)	0	> 70 g/L; > 100 g/L
Central venous pressure	16 (35%)	24 (52%)	6 (13%)	0	> 2 mmHg; < 20 mmHg
Urine output	13 (28%)	31 (68%)	2 (4%)	0	>0.5 mL/kg/h; > 30mL/h
Cardiac index	9 (20%)	36 (78%)	1 (2%)	0	> 2 L/min/m^2; >3 L/min/m^2
Mental state	8 (18%)	37 (80%)	1 (2%)	0	Sedated; cooperative; alert; not agitated
Dosage of					
Noradrenaline	36 (78%)	6 (13%)	4 (9%)	0	< 0.05 μg/kg/min; < 0.3 μg/kg/min
Adrenaline	26 (57%)	9 (20%)	11 (24%)	0	< 0.05 μg/kg/min; < 0.25 μg/kg/min
Dobutamine	26 (57%)	7 (15%)	12 (26%)	1 (2%)	< 10 μg/kg/min; < 5 μg/kg/min
Dopamine	17 (37%)	13 (28%)	10 (22%)	6 (13%)	< 10 μg/kg/min; < 5 μg/kg/min
Other drugs†					
Other criteria‡					

MAP = mean arterial pressure.
* 46 ICUs completed the physiological parameters table. A further eight ICUs (15%) stated that criteria were based on individual patient assessment, and consequently might vary between patients. Four (9%) ICUS identified a difference between criteria for commencement of IABP weaning and IABP removal. Of these, two ICUs identified a difference between drug doses only (lower doses expected before IABP removal). The other two ICUs expected a reduced pulmonary artery wedge pressure and central venous pressure before balloon catheter removal.
† Other drugs specified as important included: milrinone, 5 (11%); levosimendan, 2 (4%); and phenylephrine, 1 (2%).
‡ Other responses were: that there is no single criterion, but rather a combination of the above physiological criteria are used, 5 (11%); platelet count > 50×10^9/L, 2 (4%); and lactate, 1 (2%).

central venous pressure would decrease before balloon removal.

Criteria considered important before IABP weaning or removal were blood pressure (92%), heart rate (76%), pulmonary artery wedge pressure (59%), noradrenaline dosage (78%), dobutamine dosage (57%), adrenaline dosage (57%), and dopamine dosage (37%) (13% of respondents did not use dopamine). Criteria felt not to be important before IABP weaning or removal were mental status (80%), cardiac index (78%), urine output (68%), haemoglobin (57%), central venous pressure (52%), and gas exchange (50%) (Table 6).

Discussion

Application of IABP requires multiple supports, equipment, and experienced staff and consequently cannot be used in every hospital. However, over a quarter (28%) of Australasian ICUs use IABP in the management of circulatory support. Despite this well established practice, Australasian opinion is divided on the best method by which to withdraw support, and also the sequence of support withdrawal when IABP is combined with mechanical ventilation and pharmacological assistance. However, this variation is consistent with the lack of research and evidence-based guidelines on IABP withdrawal.

With no direct evidence suggesting that either ratio weaning or volume weaning is more successful, both are offered as legitimate options for the withdrawal of IABP support.[1-4,6] Despite this, most Australasian units wean IABP by means of ratio reduction, with fewer than a third of ICUs using volume reduction either alone or in combination. We found that ICUs reporting use of ratio reduction for weaning also reported requiring less frequent IABP reinsertion and inotropic increase after balloon removal when compared with ICUs reporting use of a variation of volume weaning. However, it is possible that ratio reduction is not as effective as volume reduction when weaning IABP. Assist ratios less than 1:1 fail to increase cardiac vein flow.[17] In addition, examination of haemodynamic outcomes of weaning IABP in heart failure found ratio reduction to result in greater haemodynamic suppression than volume weaning.[18] Haemodynamically, any reduction in intra-aortic balloon ratio appears equivalent to complete IABP withdrawal.[1,2] Australasian ICUs most likely to undertake ratio-only weaning are higher-end users of IABP, suggesting that their results may arise from a volume–outcome relationship rather than a more favourable weaning strategy.

Conversely, volume weaning may be seen as a more physiological approach. The reduction of intra-aortic balloon catheter volume will gradually increase cardiac workload. It has also been shown that larger catheter inflation volumes may further augment cardiac output.[19] Moreover, diastolic pressures augmented with IABP result in the redistribution of coronary blood flow toward ischaemic areas of the myocardium.[20,21] Combined, these arguments suggest volume weaning to be the better method of initiating withdrawal of IABP support; clinically, this appears not to be the case.

In withdrawing IABP support in the critically ill patient, it seems reasonable to maintain some cardiac assistance — continuing mechanical ventilation would ensure this. Our survey found that 47% of ICUs withdraw IABP before withdrawing ventilation in IABP weaning. However, as another 39% of responding ICUs reported having no usual order for withdrawing support, only 10% were prepared to withdraw ventilation before IABP withdrawal. Australasian opinion on the benefits of ventilation in conjunction with IABP appears clear.

Study limitations

Our survey received responses from throughout Australia and New Zealand and had a response rate of 60% overall and 70% in Level 2 and 3 ICUs. This compares favourably with the mean response rate of 60% found in an analysis of postal surveys published in medical journals.[22] The inherent limitation of postal surveys is the potential for response rate to bias results. However, direct examination of response bias for health care professional groups has generally found minimal response bias.[23-25] Menachemi et al[25] examined response bias in a postal survey examining use of electronic health records among nearly 15 000 physicians in the United States. No response bias was detected, either between respondents and non-respondents with respect to known characteristics, or between early and late respondents with respect to key variables likely to influence participation. It has been suggested that survey response rates are at best an indirect indication of the extent of non-respondent bias.[22] Our survey relied on respondents' perceptions and recall, and thus measured what was reported rather than what was done. In addition, decisions on patient care may vary between individual physicians. However, as the medical director responded on behalf of each ICU, our findings should reflect the delivery of IABP treatment in Australasia.

Conclusion

This study is the first, to our knowledge, to examine Australasian practice for IABP weaning in critically ill patients. We found that Australasian practice reflects the published literature; IABP weaning is both recommended and undertaken using a multitude of approaches. The paucity of studies on weaning, combined with an absence of evidence either supporting or refuting any method of IABP support withdrawal, indicates a clear need for further investigation.

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Competing interests

This study was undertaken in affiliation with the Queensland University of Technology, Brisbane, QLD. The authors were responsible for the design, development and implementation of the study.

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