Attitudes towards, and patterns of use, of published research evidence in clinical decision making amongst intensive care clinicians.

by

Philippa Heighes

A thesis submitted in fulfilment of requirements for the degree of

Doctor of Philosophy

Northern Clinical School, Faculty of Medicine,

The University of Sydney

Year of submission - 2017

I certify that the intellectual content of this thesis is the product of my own work and that all

the assistance received in preparing this thesis and sources have been acknowledged.

Philippa Heighes

Submitted on 31st August 2017

ABSTRACT

An *evidence-practice gap* is defined as the difference between what we know from the best available research evidence and what actually happens in current practice. The highly respected ARDSNet low-tidal-volume ventilation trial was published in 2000, however, in 2016 an observational study conducted in over 50 countries documented that up to one third of eligible patients failed to receive the ARDSNet low-tidal-volume ventilation strategy. In this thesis, we undertook a sequence of studies to better understand research evidence use in intensive care, with the intention of developing a tool that may help close evidence-practice gaps.

To better understand research evidence use, we conducted a self-administered mail-out survey of intensive care specialists in Australia and New Zealand, and a self-administered online survey of a multinational group of intensive care clinicians. Based on knowledge gained from these surveys, we developed a concise *evidence summary tool* designed to overcome 27 explicit barriers to the use of research evidence. To evaluate the evidence summary tool, we developed a clinical case-based scenario.

Ninety-three multinational intensive care clinicians were invited to review the case-based scenario and then read the evidence summary tool. Reading the evidence summary tool led to a significant *increase* in the belief that the intervention described in the tool would benefit the realistic patient in our case-based scenario (mean score change 0.32, 95% CI 0.19 to 0.46, P<0.001). Interestingly, the group most influenced by the evidence summary tool were those who appeared to be *less up to date*.

Whilst it is not known whether this success in increasing intensive care clinicians' belief in the benefit of a treatment would translate into a change in clinical practice behaviours, these promising results clearly indicate a need for further investigation into the use of evidence summary tools as an intervention to help close evidence-practice gaps.

AUTHORS CONTRIBUTION

The author, Philippa Tracy Heighes, was primarily and principally responsible for the development, design, conduct and analysis of all aspects of the studies presented within this thesis.

Publications arising from this thesis

Heighes PT, Doig GS. Intensive care specialists' knowledge, attitudes, and professional use of published research evidence: a mail-out questionnaire survey of appropriate use of research evidence in clinical practice. *J Crit Care 2014*;29(1):116-122.

The author's final version of this manuscript can be seen in Appendix F.

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

9

    Appendix A: University of Sydney HREC approval letters

    Appendix B: Cover letter and participant information for the survey titled: Use of published research in Intensive Care

    Appendix C: Questionnaire tool used in the survey titled: Use of published research in Intensive Care

    Appendix D: Cover letter and participant information for the survey titled: Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes

    Appendix E: Questionnaire tools used in the survey titled: Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes

    Appendix F: Author's final version of published Journal of Critical Care manuscript

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ANZICS	Australian and New Zealand Intensive Care Society
ARDSNet	Acute Respiratory Distress Syndrome Network
AUD	Australian Dollars
CI	Confidence Interval
CICM	College of Intensive Care Medicine
CKD	Chronic kidney disease
cm	Centimetre
°C	Degrees Celsius
EBM	Evidence Based Medicine
FDA	Food and Drug Administration
FiO_2	Fraction of inspired oxygen
GRADE	Grading of Recommendations Assessment, Development and Evaluation
ICU	Intensive Care Unit
I^2	Percentage of variation across studies due to heterogeneity
L	Litre
MA	Meta-analysis/meta-analyses
ml	Millilitre
mmHg	Millimetres of mercury
NHMRC	National Health and Medical Research Council
OR	Odds Ratio
PaO_2	Partial pressure of arterial oxygen
PaO_2:FiO_2 ratio	Ratio of partial pressure of arterial oxygen and fraction of inspired oxygen
%	Percentage
RCT	Randomised Controlled Trial
RR	Relative risk
SAPS II	Simplified Acute Physiology Score
SD	Standard deviation
US	United States

INTRODUCTION

Overview

It is universally agreed that patient health outcomes are maximised when the practice of medicine is guided by objective research evidence. To provide appropriate research evidence to guide clinical decision making, societies are making a huge investment in medical research. For example, over the 17 year period between 2010 and 2016, the National Health and Medical Research Council (NHMRC) provided over $AUD 11 billion in medical research funding.[1] Despite awareness that research evidence should guide clinical decision making, even when convincing evidence exists, studies demonstrate that medical care is not always provided in line with that evidence.

The intensive care unit (ICU) is a highly specialised area of the hospital in which the most critically ill patients with the highest risk of death are cared for. On average, an ICU accounts for ten percent of the total number of patient beds within a hospital, yet caring for critically ill patients in the ICU consumes approximately 30% of a hospital's total budget.[2, 3] Over the past ten years, the number of randomised controlled trials (RCTs) conducted in critically ill ICU patient populations each year has increased by more than 50%.[4] Unfortunately, studies consistently show that interventions that have been proven by these RCTs to reduce the mortality of critically ill patients are frequently underused.[5, 6]

The purpose of this thesis was to explore attitudes towards the use of published research evidence in intensive care medicine and, based on an understanding of factors that inhibit and/or facilitate the appropriate use of published research evidence, to develop and evaluate an intervention to improve the use of research evidence by intensive care clinicians.

Background

Use of objective research techniques to generate evidence that could be used to guide the practice of medicine appear as early as the 18th century. Historically, the first *controlled* clinical trial can be traced back to 1747.[7] James Lind, a British Naval Surgeon, conducted a comparative study of a variety of treatments for scurvy, with the aim of identifying the best way to reduce the high rate of deaths from this disease.

Lind identified 12 sailors with similar presentations of the disease scurvy. Based on his clinical experience and knowledge of the disease, he chose sailors with signs and symptoms that he believed represented a stage of the disease that was universally fatal. He took steps to ensure that all participants were provided with the same basic diet, environment and care, apart from the six interventions he had chosen for comparison.

Lind allocated two sailors to each of his six pre-determined treatment groups. The first group received treatment with 1.1 L of *cider* given daily; the second group received 25 ml of *elixir vitriol* (sulfuric acid) given daily; the third group received 18 ml of *vinegar* three times per day; the fourth group received 284 ml of *seawater* daily; the fifth group received a *medicinal paste* made up of garlic, mustard seed, dried radish root and gum myrrh plus 284 ml of barley water; and finally the sixth group received two *oranges* and one *lemon* every day for six days. Lind found that those sailors treated with the oranges and lemon 'improved and recovered faster' than those treated with any other intervention.[7, 8]

Interestingly enough, this example of what is generally recognised as the first controlled trial also provides us with the first example of an *evidence-practice gap*. An *evidence-practice gap* is defined by the Australian NHMRC as "the difference between what we know from the best available research evidence and what actually happens in current practice."[9]

As previously outlined, James Lind conducted his controlled trial in 1747 and published the results in book form in 1753.[7] However, British Royal Navy records document that it was not until 1795 that it became common for British naval ships to carry citrus fruit on board to ensure sailors didn't develop scurvy.[8] During this 42 year *evidence-practice gap* it has been estimated that hundreds of thousands of British sailors lost their lives to scurvy.[8]

The disconnect between what we know and what we do

Despite a general awareness that patient benefits are maximised when research evidence is used to guide clinical decision making, even when convincing evidence exists, medical care is not always provided in line with that evidence.[10]

Recently, the NHMRC recognised the potential importance of this issue by proclaiming the investigation of methods for reducing evidence-practice gaps as a national research priority.[9] In December 2003, the Australian National Institute of Clinical Studies, a national agency tasked specifically with closing the gaps between evidence and practice in health care, published a report which highlighted areas for further research within Australia.[11] This report broadly classified evidence-practice gaps into one of two types: 1) When evidence for a specific intervention exists, yet that intervention has failed to translate into routine use in clinical practice, then this is a situation of *underuse* or; 2) When evidence exists for a specific intervention to be used in a specific condition (e.g. antibiotics for pneumonia), yet the intervention is often freely given to patients who do not have the specific condition (e.g. instead of pneumonia, antibiotics are given to patients with a head cold) then this is a situation of *overuse*.

Evidence-practice gaps in medical practice

The concept of an evidence-practice gap in medicine is not new. As previously outlined, the results of what is generally considered to be the first controlled clinical trial also provides an example of the first evidence-practice gap: citrus fruit for the prevention of

scurvy did not gain widespread use until 42 years after publication that demonstrated its effectiveness.[7,8] There are many more recent examples.

A landmark meta-analysis published in 1992 provides a compelling demonstration of an evidence-practice gap with regards to the use of thrombolytics as a primary treatment for acute myocardial infarction.[12] Antman and colleagues conducted a comparative study contrasting the *knowledge* of appropriate treatment, as ascertained from the results of meta-analyses of RCTs, and the *recommendations* for appropriate treatment, as ascertained from expert review papers and textbooks. Their study demonstrated there was a time delay between the appearance of convincing evidence from cumulative meta-analyses and routine treatment recommendations made by experts (see **Figure 1**).

Antman *et al.* undertook a review of 182 RCTs, 43 review articles and 100 textbook chapters. They documented that *recommendations* for the routine use of thrombolytics first began to appear in expert review papers and textbook chapters in 1986. This was *13 years after* their cumulative meta-analysis of ten RCTs including 2,544 patients demonstrated a significant mortality reduction from primary treatment of acute myocardial infarction with thrombolytics.

Figure 1. Knowledge of effectiveness vs. recommending treatment (from Antman *et al.*[12])

A. Thrombolytic Therapy

Odds Ratio (Log Scale) — Textbook/Review Recommendations

Year	Cumulative RCTs	Pts	Odds Ratio	Routine	Specific	Rare/Never	Experimental	Not Mentioned
1960	1	23						
	2	65						
1965	3	149						21
								5
1970	4	316					1	10
	7	1793					1	2
	10	2544	P<.01				2	8
	11	2651						
1975	15	3311						7
	17	3929						
	22	5452						8
1980	23	5767			1			12
	27	6125	P<.001	M	1		8	4
	30	6346		M	1		7	3
1985	33	6571		M				
	43	21059	P<.00001	M 5	2		2	1
	54	22051						
	65	47185		M 15	8			1
	67	47531						
1990	70	48154		M 6	1			

Favors Treatment   Favors Control

Blue line: Approximate time that treatment was known to be effective. **Red line:** approximate time that treatment recommendations were being made in the literature.

meta-analysis of ten RCTs including 2,544 patients demonstrated a significant mortality reduction from primary treatment of acute myocardial infarction with thrombolytics.

Evidence-practice gaps don't just exist in the form of a time-lag between knowledge

and action; they can also be documented by studying the *proportion* of delivered care that is consistent with best evidence. For example, in order to determine the proportion of medical care provided to citizens of the United States that was consistent with current evidence, McGlynn and colleagues conducted a retrospective study that evaluated the delivery of medical care processes to 6,712 people.[13] This study was conducted between October 1998 and August 2000, and found that only 54.9% (95% CI, 54.3 to 55.5) of delivered care was consistent with the best available evidence.

The study sample was obtained from a list of households that had previously participated in the Community Tracking Study conducted by the Centre for Studying Health System Change,[14] which documented insurance coverage, patterns of usage of health care services, and health status of a random sample of the American population.

McGlynn *et al.* randomly selected households that had participated in the Community Tracking Study and obtained consent for additional information to be collected. Written consent was obtained from households willing to participate in the study to access medical records, and photocopies of these records were obtained for evaluation. Participants were asked to complete a telephone interview regarding their health history and to provide details of all health care providers (individual or institutional) who they had seen in the last year.

At least one medical record was obtained for 6,712 (89%) of the 7,528 eligible people who volunteered to participate. Analysis was conducted on the delivery of care for 439 indicators in 30 conditions. An aggregate score was determined by dividing all instances in which the participant *received* recommended care by the number of times the participant was *eligible* for recommended care.

Overall the study found that the 6,712 participants received only 54.9% (95% CI, 54.3 to 55.5) of the care episodes that could have been recommended based on best available evidence. The highest rate of recommended care delivery was for the conduct of an annual

medical check-up for patients with hypertension: Seventy-three percent (95% CI, 71.5 to 75.3) of patients with hypertension did receive annual check-up visits. The lowest rate of recommended care delivery was for smoking cessation advice in patients with chronic obstructive pulmonary disease: Only 18.3% (95% CI, 16.7 to 20.0) of smokers with chronic obstructive pulmonary disease received smoking cessation advice.

Underuse of care supported by evidence was documented more often than technical overuse evidence-practice gaps. Whilst 45% (95% CI, 45.8 to 46.8) of participants were *not provided with care* that was recommended by research evidence, only 11% (95% CI, 10.2 to 12.4) of participants were provided with care that was deemed to result from *overuse* of recommended care.

In a similar study conducted in Australia, Runciman and colleagues classified care as inappropriate, based on best evidence recommendations, in 43% (95% CI, 39.9 to 45.7) of eligible encounters.[15]

Runcimen *et al.* based their methodology primarily on the methods used by McGlynn *et al.,*[13] with some modifications: Participants were recruited from rural and remote areas in addition to metropolitan areas, and onsite medical records were reviewed rather than copied records.

The study evaluated the delivery of care for 22 health conditions against indicators of appropriate care developed by clinical experts' review of the evidence. Potential participants (15,292) residing in New South Wales or South Australia were contacted via telephone numbers randomly chosen from the White Pages telephone directory. The final study sample included 1,154 consenting participants.

Indicators of care were evaluated during 35,573 eligible encounters between study participants and their health care providers, with recommended care delivered appropriately 57% (95% CI, 54.3 to 60.1) of the time. The highest overall compliance was with the delivery

of surgery for coronary artery disease, with 90% (95% CI, 85.4 to 93.3) of patients deemed to be eligible actually receiving surgery. The highest level of overuse was documented with regards to antibiotic prescribing, with only 19% (95% CI, 0.1 to 77.3) of prescriptions deemed to be clearly consistent with current recommendations for use.

Overprescribing: an important evidence-practice gap

The over-prescribing of medications provides a good example of an *overuse* evidence-practice gap. Often a medication may have proven effect in a specific patient population or to treat a specific disease, yet the medication is prescribed to patients with a disease process for which the evidence does not document a treatment effect.

The first major example of overprescribing comes from a study published in 1963.[16] Forsyth *et al.* conducted an observational study assessing prescribing practices amongst general practitioners in the United Kingdom. The study demonstrated that only 9.9% of prescriptions were written to treat a condition for which objective research showed the drug was proven to be effective.

The study sample was obtained by requesting participation from active general practitioners in a small northern industrial town in England, and collecting prescribing information on all of their patient consultations. This information included patient demographics, location of the contact with the patient, major diagnostic group, estimated severity of illness (trivial, acute ordinary, acute serious, chronic ordinary, chronic serious) and therapeutic intent of drugs prescribed to one of five grades (specific, probable, possible, hopeful, and placebo).

During the two week study period, there were a total of 9,405 consultations from the combined practice populations of an estimated 45,000 people. Sixty-six percent of consultations resulted in at least one prescription being written for a patient, with a total of 9,575 items prescribed. Forty-three percent of the prescriptions were written for *generic*

medications whilst 57% of the prescriptions were for drugs protected by a patent (proprietary prescriptions).

In assessing the prescribing patterns, an analysis was performed on the therapeutic intent of proprietary prescriptions and generic prescriptions. This analysis demonstrated that in proprietary prescriptions, 9.3% (467/5,039) were written for an indication where the drug was proven to be effective by research evidence, with similar results for generic prescriptions where 10.6% (432/4,055) were written for an indication where the drug was proven to be effective by research evidence.

In 1987, Chassin and colleagues conducted a study that documents that interventional procedures can also be overused.[17] This project focussed on the performance of three specific procedures (coronary angiography, carotid endarterectomy and upper gastrointestinal tract endoscopy), and reviewed records of physician claims from Medicare insurance carriers located in a broad range of states (Arkansas, Colorado, Iowa, Massachusetts, Montana, Pennsylvania, South Carolina and Northern California).

Ninety percent (819/913) of the physicians approached by the investigators participated in the study, with these physicians responsible for performing 4,988 study procedures. A random sample of cases for all three procedures was selected in each study site directly from Medicare claims data.

An expert panel judged that 32.4% (95% CI, 29.8 to 34.0) of the randomly selected 1,302 carotid endarterectomies were deemed to have been performed for an indication that was *not* supported by current research evidence. For coronary angiographies, 17.4% (95% CI, 15.6 to 19.3) of 1,677 procedures were performed for an indication that was *not* consistent with current research evidence, and for upper gastrointestinal endoscopies, 17.2% (95% CI, 15.4 to 19.1) of the 1,585 randomly selected procedures were performed for an indication *not* consistent with research evidence.

How much medical practice can be based on objective research evidence?

In 1995 Ellis and colleagues conducted an observational study to document the diagnosis and treatment of patients under their care in order to evaluate how much of their medical practice was based on research evidence.[18] They found that 53% (58/109) of their patients received care for their primary diagnosis based upon direct evidence from RCTs.

The clinical investigative team included seven medical practitioners of various skill levels: one professor, one senior registrar, two registrars, one senior house officer, two house officers and ten medical students. The study population included every inpatient treated by the clinical investigative team during the month of April 1995 at the John Radcliffe Hospital, a university affiliated teaching hospital in Oxford.

At the time of death or discharge, or at the end of the month if the patient was still in hospital, the investigators met and by consensus decided on the primary diagnosis of the patient and the primary intervention that represented the most important attempt to cure, alleviate or care for the patient in respect of his or her primary diagnosis. Primary interventions were classified into one of three groups: (1) Intervention with evidence from RCTs; (2) Intervention with convincing non-experimental evidence or (3) Intervention without substantial evidence. Primary interventions that were classified as either category (1) or category (2) were deemed to be evidence based.

A total of 121 patients were cared for by the clinical investigative team during the data collection period. A primary diagnosis was not made for 12 patients that were admitted on the last day of the study, resulting in a total of 109 patient diagnoses being evaluated in the study sample.

On evaluation, 53% (58/109) of patients received care for their primary diagnosis based upon evidence from RCTs (category 1) with an additional 29% (32/109) receiving care for their diagnosis based upon other types of research evidence (category 2). Examples of

interventions classified as convincing non-experimental evidence were those that investigators believed had face validity so high that it would be unethical to conduct an RCT, for example, transfusion in massive haemorrhage.

In 1990, Dubinsky *et al.* conducted a similar study to assess the percentage of National Institutes of Health recommendations for Medicare item coverage that were based on RCTs or other objective research evidence.[19] In the United States, the National Institutes of Health is involved in the conduct of assessments of new medical technologies in order to aid in the Medicare coverage decision making process. This study reported that only 20.6% (26/126) of the National Institutes of Health recommendations were based on RCTs or other objective research evidence.

This study by Dubinsky *et al.* involved a retrospective review of the National Institutes of Health records of new coverage decision assessments over a six year period, between 1981 and 1987. Coverage decisions were classified into one of five categories: 1) strong positive recommendations based on RCTs or other objective clinical studies; 2) positive recommendations based on RCTs or other objective clinical studies; 3) positive recommendations based on consensus of expert opinion; 4) negative recommendations based on inconclusive or conflicting expert opinion; and 5) negative recommendations based on evidence of ineffectiveness or lack of efficacy based on RCTs or other objective clinical studies.

Table **1** (next page) summarises the category of recommendation made and the number and percentage in each category.

Table 1. Category of evidence supporting National Institute of Health recommendations.

Category of recommendation	Number (n/N)	Percentage %
1 – Strong positive based on RCTs or other clinical trials	2/126	1.6
2 – Positive based on RCTs or other clinical trials	21/126	16.7
3 – Positive based on consensus or expert opinion	55/126	43.6
4 – Negative based on inconclusive or conflicting expert opinion	45/126	35.7
5 – Negative based on RCTs or other clinical trials	3/126	2.4

During the six year study period, the National Institutes of Health generated 126 recommendations for Medicare item coverage, with 20.6% (26/126) of these recommendations based on RCTs or objective clinical studies. A *positive* recommendation for an item to be covered by Medicare was only supported by RCTs or objective clinical studies in 29.5% (23/78) of the cases. The remaining 70.5% (55/78) of items that the National Institutes of Health recommended be covered by Medicare relied on expert opinion rather than scientific evidence.

Intensive Care Medicine

The Intensive Care Unit (ICU) is a highly specialised area of the hospital in which the most critically ill patients with the highest risk of death are cared for. On average, an ICU accounts for ten percent of the total number of patient beds within a hospital, yet caring for critically ill patients in the ICU consumes approximately 30% of a hospital's total budget.[2, 3] Over the past 10 years, the number of RCTs conducted each year in critically ill ICU patient populations has increased by more than 50%,[4] but formal studies consistently show that even interventions that have been proven to reduce mortality by these RCTs are underused.[5, 6]

In Australia and New Zealand, a well known medical specialist interest group for Intensive Care Medicine is the Australian and New Zealand Intensive Care Society (ANZICS). In addition to involvement in specialist medical education and ICU research activities, the society records information about patients admitted to adult and paediatric ICUs

within Australia and New Zealand. The ANZICS Adult Patient Database currently contains data from over 1.6 million individual episodes of care contributed from 165 ICUs across Australia and New Zealand.

During 2015, the ANZICS Adult Patient Database reported that 147,060 critically ill patients were admitted to an ICU, with 12,367 (8.41%) of these patients dying before hospital discharge.[20]

Costs of Intensive Care

In 2010 Halpern and colleagues published a paper describing the patterns of use and costs of caring for patients in the ICU in the United States.[3] The burden of caring for critically ill patients is significant. The medical care of a critically ill patient in the ICU costs approximately three times more than the provision of medical care for a standard hospital patient. Furthermore, the costs of ICU care are also rising out of proportion to the costs of caring for the standard hospital patient, by an additional seven percent increase every five years.

This study used the data collected by Medicare and Medicaid in the Hospital Cost Reporting Information System to evaluate costs from 2000 to 2005. Over the 5 year study period, Halpern *et al.* reported that the overall daily cost of care for a patient in the ICU rose from $USD 2,698 to $USD 3,518 per patient per day, a 30.4% increase. Over the same time period, the overall daily cost of care for a standard hospital patient rose from $USD 899 to $USD 1,153, representing a 22% increase. At the end of the study period in 2005, caring for the ICU patient was three times ($USD 3,518/$USD 1,153) more expensive than caring for the standard hospital patient. These cost estimates are similar to estimates reported by Australian investigators in publications from the same time period.

Rechner *et al.* conducted a retrospective review of data from critically ill patients admitted to the ICU at The Royal Brisbane and Women's Hospital.[21] This study was

conducted using criteria set by the European Society of Intensive Care Medicine Health Services Research and Outcome Working Group on Cost Effectiveness. All key costs were identified: staff costs, clinical support services, disposables and capital equipment.

Data was collected over a 12 month period from July 2002 to June 2003. During this time 1,615 critically ill patients were admitted to the ICU, resulting in 5,692 ICU care days. The total ICU based expenditure for the study period was $AUD 15,915,964 resulting in an average daily cost of care for a critically ill ICU patient of $AUD 2,670.

Moran *et al.*[22] also conducted a study to estimate the cost of caring for critically ill ICU patients in Australia. They evaluated data collected in three South Australian adult ICUs for a nine month period in 1991. Cost data was collected relating to all management activities and interventions including drug administration, procedural supplies, pathology costs, radiology costs, physiotherapy costs, nursing staff costs, medical staff costs, overhead costs and other residual costs related to operating the ICU. All costs were indexed to 2002 costs, which was the year before publication.

Over the nine month study period, 1,333 critically ill patients were admitted to the study ICUs. These patients required 5,198 days of care in the ICU with a total budget of $AUD 12,449,210 which translates to an average daily cost of care for a critically ill ICU patient of $AUD 2,395.

Accounting for the difference in exchange rates between the Australian and US dollar from 2002 until 2005, the studies by Halpern, Rechner and Moran demonstrate that the costs of caring for a critically ill patient in the ICU are remarkably similar in the two countries.

Research in Intensive Care

Because critically ill patients face a high risk of death and require costly care, undertaking objective research to guide clinical decision making has become a priority.

In 2015, Doig *et al.* published a review identifying the number of RCTs conducted in critically ill ICU patients that were indexed on PubMed[4] (see Figure 2). PubMed is the National Library of Medicine's free web search service that provides access to MEDLINE, one of the largest databases of citations and abstracts to medical, nursing, dental, veterinary, health care, and preclinical sciences journal articles.

Figure 2. Cumulative distribution of intensive care RCTs indexed on PubMed (from Doig *et al.*[4]).

PubMed was searched using medical subject headings to identify randomized controlled trials published in the field of intensive care or critical care medicine. A total of 11,630 publications were indexed by PubMed between 1971 and 2013 using the above terms.
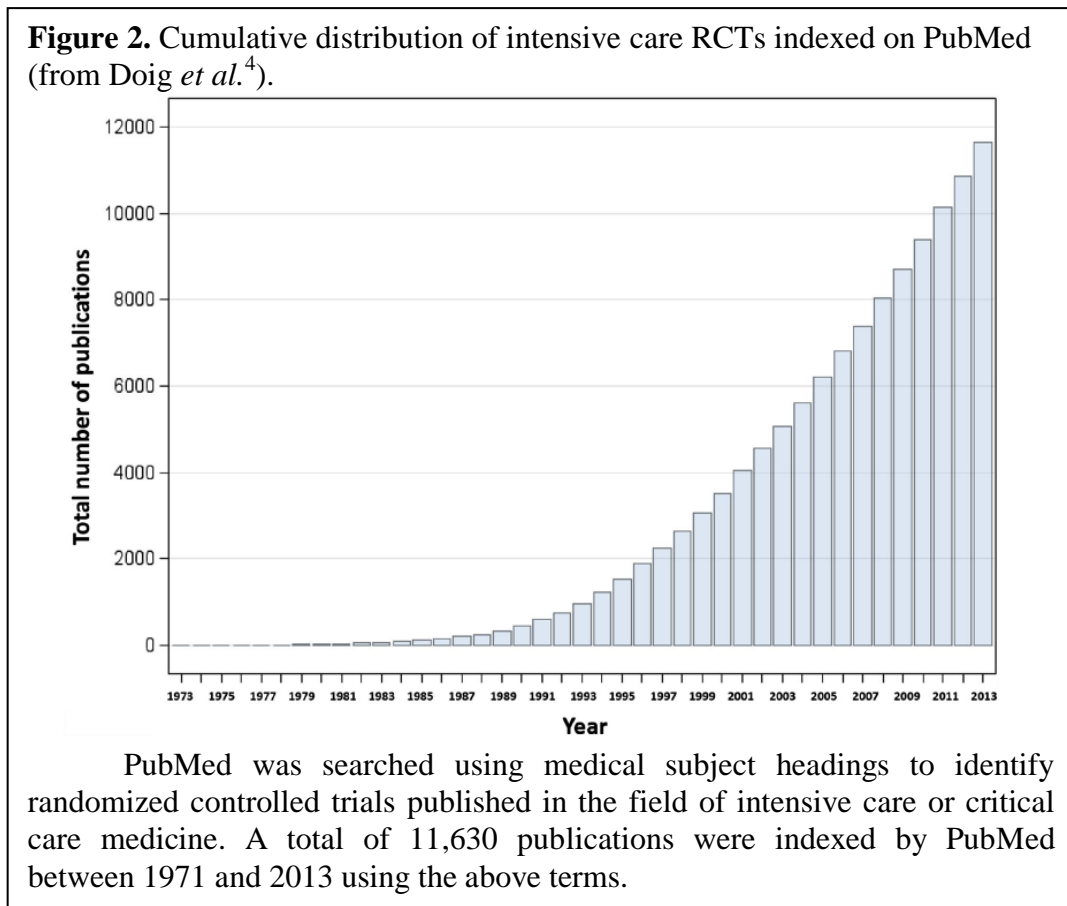
In their review paper, Doig *et al.* report that over the last 10 year period of their study, there were 515 new RCTs published on intensive care topics in 2003, whilst in 2013 there were 763 new RCTs published. This rate of growth represents a doubling in the number of new publications every 14 years.[4]

Evidence-practice gaps in Intensive Care

Many clinical trials published in critically ill ICU patient populations are accepted to define landmark and life saving interventions, yet there is clear evidence these interventions are under-used. The Acute Respiratory Distress Syndrome Network (ARDSNet) low-tidal-

volume trial is accepted to be a landmark trial in critically ill ICU patients and also illustrates a key evidence-practice gap.[23,24,6]

The National Institute of Health funded ARDSNet investigators conducted an 861 patient RCT in the United States.[23] This study evaluated the benefits of using a novel mechanical ventilation strategy (lower tidal volume and restricted plateau pressure) compared to traditional mechanical ventilation in patients with Acute Respiratory Distress Syndrome. Acute Respiratory Distress Syndrome arises when inflammation in the lung severely reduces gas exchange, resulting in life threatening breathing difficulties. The ARDSNet investigators reported that mechanical ventilation of patients with Acute Respiratory Distress Syndrome using the ARDSNet low-tidal-volume ventilation strategy significantly reduced mortality by 22% (relative risk reduction, P=0.007).

The study was conducted over a three year period, from March 1996 to March 1999 at ten University Hospitals in the United States. Intubated and mechanically ventilated patients were considered for inclusion in the study if they met the traditional diagnosis of Acute Respiratory Distress Syndrome: an acute deterioration in oxygenation status as indicated by a drop in the ratio of partial pressure of oxygen in the blood to the fraction of inspired oxygen being delivered (PaO_2:FiO_2 ratio) of 300 or less; bilateral pulmonary infiltrates evident on chest x-ray; and no clinical evidence of left atrial hypertension (pulmonary capillary wedge pressure less than 18 cm of water if measured). Patients were excluded if it was more than 36 hours since they first met the three inclusion criteria above.

Allocation concealment was maintained by using an interactive centralised voice system with patients randomly assigned to receive the ARDSNet mechanical ventilation strategy or traditional mechanical ventilation. Traditional mechanical ventilation patients received ventilation with an initial tidal volume of 12 ml per kilogram predicted (ideal) body weight, whereas the ARDSNet low-tidal-volume ventilation patients received an initial tidal

volume of 6 ml per kilogram of predicted (ideal) body weight. Furthermore, traditional mechanical ventilations patients were allowed a maximum plateau pressure of 50 cm of water whilst ARDSNet low-tidal-volume ventilation patients were allowed a maximum plateau pressure of 30 cm of water. All other aspects of mechanical ventilation were similar between groups.

Fewer patients who were randomised to receive the ARDSNet low-tidal-volume ventilation strategy died compared to patients who received traditional mechanical ventilation (171/429 deaths for traditional mechanical ventilation vs. 134/432 deaths for ARDSNet low-tidal-volume ventilation, P=0.007).

Furthermore, of the patients who were alive, fewer patients who received ARDSNet low-tidal-volume ventilation required a mechanical ventilator by the end of the 28 day study follow-up period (284/432 for traditional mechanical ventilation vs. 236/429 for ARDSNet low-tidal-volume ventilation, P < 0.001). In addition, the severity of illness of the patients who received ARDSNet low-tidal-volume ventilation was improved, as represented by more days alive without non-pulmonary organ failure (12 days for traditional mechanical ventilation vs. 15 days for ARDSNet low-tidal-volume ventilation, P=0.006).

Universal acceptance of the importance of the results of the ARDSNet low-tidal-volume ventilation trial is illustrated by clinical recommendations incorporated into major international clinical guidelines.[25-28] In 2004, a major international guideline for the management of severe sepsis and septic shock in critically ill ICU patients, the Surviving Sepsis Campaign Guideline, was published.[25] This guideline was developed by 68 recognised intensive care experts from 30 major international specialist medical organisations from around the world including the European Society of Intensive Care Medicine (ESICM), the US based Society of Critical Care Medicine (SCCM) and the Australian and New Zealand Intensive Care Society (ANZICS). Committee members were selected and organised into sub

groups according to their expertise and allocated to an assigned area of the guideline that addressed a clearly defined clinical question. Committee chairs developed search terms for each subgroup, and groups then completed a comprehensive electronic search of MEDLINE, EMBASE and the Cochrane Library database to identify all articles published relevant to their clearly defined clinical question. Using the GRADE system,[29] a methodological approach to rating the quality of evidence, an assessment of quality was conducted for the evidence supporting clinical recommendations relevant to each clinical question. Recommendations for the implementation of interventions were then made based upon the quality assessment conducted.

Use of the ARDSNet low-tidal-volume ventilation strategy received a *Grade 1 recommendation*, which is the strongest level of recommendation, for the ventilation of critically ill patients with Acute Respiratory Distress Syndrome.

Since the initial Surviving Sepsis Campaign Guideline development process was published in 2004, the guideline has been updated three times, resulting in publications in 2008, 2013 and 2017.[24-26, 30] In each update, the recommendations for mechanical ventilation in patient with sepsis induced Acute Respiratory Distress Syndrome have remained unchanged. The 2017 publication makes a *Strong recommendation* (equivalent to Grade 1 in previous grading system) for the use of ARDSNet low-tidal-volume ventilation strategy (6 ml/kg) in adult patients with sepsis induced ARDS, and a *Strong recommendation* for maintenance of plateau pressures less than 30 cm of water in patients with sepsis induced severe ARDS.[26]

Despite universal acceptance of the results of the ARDSNet study, and promotion of the results in highly respected international guidelines endorsed by numerous national societies, a recently conducted major observational study demonstrate an evidence-practice

gap exists resulting in *underuse* of the ARDSNet low-tidal-volume mechanical ventilation strategy.[6]

Published in 2016, a prospective observational study by Bellani *et al.* measured the adherence to the ARDSNet low-tidal-volume ventilation strategy in patients with the Acute Respiratory Distress Syndrome.[6] The study involved the collection of data for all mechanically ventilated patients from 50 different countries. Patients were excluded if they were less than 16 years old or if there was an inability to obtain informed consent.

A total of 459 ICUs from 435 different hospitals in 50 countries throughout the world participated in the study, with 2,377 eligible patients admitted to these ICUs during the study period. Patients were followed up until hospital discharge, or for a maximum of 90 days if the patient was not already discharged by day 90.

A diagnosis of Acute Respiratory Distress Syndrome was made by the study investigators using prospectively collected patient data with a computer algorithm designed to recognise the presence of the Berlin criteria (see **Table 2**).[31]

In the 915 critically ill patients objectively diagnosed with the Acute Respiratory Distress Syndrome, 36.3% (332/915) of eligible patients *did not* receive the ARDSNet low-tidal-volume ventilation strategy. With such a clear evidence–practice gap around the ARDSNet low-tidal-volume trial which is considered a landmark clinical trial, it is not surprising that many other evidence-practice gaps also exist in intensive care.[5,6]

Table 2. Berlin criteria for the diagnosis of Acute Respiratory Distress Syndrome.

- acute hypoxaemic respiratory failure as indicated by a drop in the ratio of partial pressure of oxygen in the blood to the fraction of inspired oxygen being delivered (PaO_2:FiO_2 ratio) to 300 or less
- onset within one week of known clinical insult, or new worsening respiratory symptoms
- bilateral opacities on chest x-ray not explained by effusions, lobar or lung collapse or nodules
- respiratory failure not of cardiac origin or fluid overload

Between 2008 and 2011, Guerin *et al.* recruited critically ill patients from 27 ICUs into an RCT to investigate whether the use of prone positioning early in the treatment of patients with *severe* Acute Respiratory Distress Syndrome may reduce deaths.[5] Traditionally, ICU patients who need mechanical ventilation are cared for whilst lying on their backs (supine), generally with the head of the bed slightly raised. The concept of *proning* means the mechanically ventilated patient is positioned face down (prone) for up to 16 hours per day and then positioned supine for the remainder of the day.

The study included adults with *severe* Acute Respiratory Distress Syndrome who were intubated via the endotracheal route and receiving mechanical ventilation for less than 36 hours in total. Severe Acute Respiratory Distress Syndrome was defined as a $PaO_2:FiO_2$ ratio of less than 150, with a fraction of inspired oxygen (FiO_2) of less than 0.6, a positive end expiratory pressure equal to 5 cm of water or more, with a tidal volume of about 6 ml per kilogram of predicted (ideal) body weight. If a patient met these inclusion criteria, after a 12 to 24 hour stabilisation period of mechanical ventilation the criteria were re-confirmed, at which point patients were then randomised.

Over a three and a half year period, 3,449 patients presented with Acute Respiratory Distress Syndrome to the 26 French ICUs and one Spanish ICU that participated in the study. This resulted in 466 patients with *severe* Acute Respiratory Distress Syndrome being included in the study.

Allocation concealment was maintained by using a web based server to randomise patients to the prone position group or the supine group. Patients randomised to the prone group were placed in the prone position within one hour of randomisation and remained prone for at least 16 consecutive hours. Patients assigned to the supine group were all nursed with the head of the bed slightly raised. Mechanical ventilation was standardised in both groups through the use of a guideline delivering a low-tidal-volume and plateau pressure limited

ventilation strategy based upon the ARDSNet protocol.[23] Patients were followed up until day 90 with analysis performed on an intention-to-treat basis.

The primary outcome of the study was mortality at Day 28, with results indicating a significantly lower mortality rate in prone patients than in supine patients (16.0% vs. 32.8%, P<0.001). This mortality benefit remained significant at Day 90 follow-up (23.6% vs. 41.0%, P<0.001).

The mortality benefit attributable to proning patients with severe Acute Respiratory Distress Syndrome demonstrated by Guerin's 466 patient RCT has been confirmed by two systematic reviews and meta-analyses conducted by independent groups of investigators that considered the results of seven additional RCTs.[32, 33]

In 2014, Sud and colleagues published a systematic review and meta-analyses of RCTs investigating the use of prone positioning in patients with *severe* Acute Respiratory Distress Syndrome.[32] The literature search was comprehensive with a search strategy designed to retrieve relevant trials from MEDLINE, EMBASE and CENTRAL. In addition, bibliographies and conference proceedings were hand searched and clinical trial registries and databases were reviewed for any unpublished clinical trials. No language restrictions were applied during the search strategy, with details of the full search strategy readily available as an appendix to the publication.

Eligibility criteria were clearly identified. RCTs and quasi-randomised trials that were conducted in adults and children with *severe* Acute Respiratory Distress Syndrome supported by mechanical ventilation were included. The primary outcome of interest was mortality with secondary outcomes being changes in oxygenation and adverse events.

The methodological quality and risk of bias in each trial was assessed with full reporting of randomisation methods, allocation concealment, blinding methods and completeness of follow up after randomisation. These assessments were performed

independently by three of the authors with disagreements resolved by consensus. A table outlining the full results of the risk of bias assessment was included in the publication. All outcomes were analysed using an intention-to-treat approach.

Sud *et al.*'s literature search identified 238 potential studies. After screening of abstracts and titles, 22 RCTs were retrieved for detailed review, with 11 RCTs recruiting a total of 2,341 patients selected for inclusion. The primary analysis in this publication was based on clinical trials where low-tidal-volume ventilation was mandated. Within six trials including 1,016 patients where low-tidal-volume ventilation was mandated, the use of prone positioning compared to supine positioning significantly reduced mortality (RR 0.74, 95% CI 0.59-0.95, $I^2 = 29\%$). An *a priori* subgroup analyses was conducted to assess whether the duration of prone positioning sessions had an impact on mortality. This demonstrated that prone positioning led to a significant reduction in mortality when the duration of the session was at least 16 hours per day (RR 0.77, 95% CI 0.64-0.92, $I^2=21\%$).

In the second systematic review and meta-analyses on this topic, also published in 2014, the investigators also conducted a thorough search to identify RCTs where the use of prone positioning was compared to supine positioning in patients with *severe* Acute Respiratory Distress Syndrome receiving mechanical ventilation.[33]

A computerised literature search was conducted in databases including MEDLINE, EMBASE, Lilacs and the Cochrane Central Register of Controlled trials. Specific medical subject heading terms designed to identify RCTs where the use of prone positioning was compared to supine positioning in adult patients with Acute Respiratory Distress Syndrome during conventional mechanical ventilation were chosen. A clear process was applied for the selection of studies by two independent reviewers, with a third reviewer utilised to resolve disagreements. Data was extracted independently by two authors using a standardised data collection form. The primary outcome of mortality was either collected directly from reported

data in individual trials, or determined by enhancing Kaplan-Meier plots for estimation of time to 60 day mortality. One corresponding author was approached to provide missing data for one included trial where a mortality rate could not be determined. An *a priori* analysis was planned to stratify trials by high-tidal-volume ventilation versus low-tidal-volume ventilation.

The quality of individual trials was evaluated at a study level by considering the method employed to maintain allocation concealment, completeness of follow-up, blinding, crossover between study arms, post-hoc exclusions and early trial discontinuation.

The authors obtained 643 citations from their initial search, from which 336 unique abstracts were identified. Following the exclusion of 108 review articles, commentaries, meta-analyses or abstract only papers, 228 abstracts were reviewed with 217 of these excluded for reasons such as not being a study of Acute Respiratory Distress Syndrome, not containing proning as a study intervention, or the trial design was not randomised. From 11 full text articles that were retrieved and reviewed in detail for eligibility seven RCTs that enrolled 2,119 patients were included in the final meta-analyses. One trial was stratified at randomisation depending on severity of Acute Respiratory Distress Syndrome, the authors pre-specified that this trial was treated as two separate trials during analysis.

The quality assessment of the included studies is reported in the publication, with all studies adhering to randomisation method using a centralised or sealed envelope process to maintain allocation concealment. Follow up for the primary outcome of mortality was complete, with only two patients lost to follow up in two separate trials. The patients enrolled in the included studies were critically ill, with Simplified Acute Physiology Scores (SAPS II) ranging from 37 to 47 with between 40 and 802 patients enrolled in each trial. Changes in ventilation practice can be seen within the studies when reviewed chronologically, with tidal volumes reducing over time. Earlier trials published prior to the landmark ARDSNet trial used tidal-volumes greater than 8 ml per kilogram predicted (ideal) body weight whereas

trials published after the ARDSNet study used lower tidal volumes, between 6 to 8 ml per kilogram predicted (ideal) body weight.

The primary meta-analysis of included studies did not demonstrate a significant difference in mortality (risk ratio at 60 days 0.83, 95% CI 0.68-1.02; P=0.073) however when the *a priori* stratified analysis of high versus low-tidal-volume was performed, there was a significant mortality benefit with prone positioning when low-tidal-volume ventilation was delivered (risk ratio 0.66, 95% CI 0.50-0.86; P=0.002). Heterogeneity amongst trials was reduced when stratified according to tidal volume (I^2=11% for high volume and I^2=25% for low-tidal-volume strata) whereas when all trials were pooled, there was moderate heterogeneity (I^2=64%).

Despite the cumulative evidence from the primary RCT by Guerin *et al.* and the two meta-analyses outlined above, a recent major observational study demonstrates that many patients in the ICU who would benefit from prone positioning do not receive this intervention. In addition to assessing use of the ARDSNet low-tidal-volume ventilation in critically ill ICU patients with Acute Respiratory Distress Syndrome, the 2016 study published by Bellani and colleagues also measured the implementation of prone positioning in patients with *severe* Acute Respiratory Distress Syndrome.[6]

During the study period, Bellani *et al.* screened 29,144 admissions to the 459 participating ICU's located in 50 different countries. Of these patients, 729 were diagnosed as having *severe* Acute Respiratory Distress Syndrome. Severe Acute Respiratory Distress Syndrome was defined as Acute Respiratory Distress Syndrome with a PaO_2:FiO_2 ratio of 100 or less. Using this definition, which was much more *severe* than the definition applied by Guerin *et al.*,[5] Bellani *et al.* reported that only 16.3% (119/729) of eligible patients received proning.

Understanding the use of research evidence in clinical practice

Across almost all disciplines of medicine, overuse and underuse evidence-practice gaps can be documented.[5-7, 12, 13, 15-18] There are many possible barriers that prevent clinicians incorporating the results of research evidence into their clinical practice. Modifiable barriers are barriers that can be targeted for change such as pre-existing attitudes, a lack of time to read and appraise primary research evidence, levels of knowledge and understanding of principles and key aspects of research evidence.[34-36]

Attitudes towards using research evidence

Change management theories consistently highlight that a *positive attitude* towards a new behaviour (e.g. stopping smoking) is an important and necessary first step towards adopting that new behaviour.[37, 38] Clinicians' attitudes towards research evidence and its use to guide their clinical practice have therefore been studied and reported extensively in medical literature.[34-36, 39-45] These studies universally report that clinicians have *positive attitudes* towards using research evidence to guide clinical practice decisions.[34, 35, 39-45]

In 1998, McColl and colleagues published a landmark study reporting the attitudes of general practitioners towards the use of research evidence in clinical practice.[34] In order to achieve the objectives of the study, the authors developed a self-administered mail out questionnaire to assess respondents' attitudes, knowledge, self-reported use and perceived barriers to using research evidence to guide their clinical practice.

Utilising a National Database of general practitioners, a random sample of 25% (452/1,808) of the general practitioners listed in the Wessex region of England was selected with computer based random number generation. Only practising general practitioners were eligible for inclusion. After the initial invitation to participate, at least two consecutive follow up reminders were sent.

The questionnaire was mailed out to 450 practising general practitioners. In total, 302 completed questionnaires were returned resulting in a response rate of 67% (302/450).

Respondents were asked to indicate their level of agreement using a visual analogue scale with responses ranging from 0 (strongly disagree) to 100 (strongly agree) with the statement *practising evidence based medicine improved patient care.* From the 293 general practitioners responding to this question, the median score reported was 70 (25th to 75th percentile; 57 to 80). However when asked to provide an *estimated percentage of respondent's clinical practice that is evidence based* using a visual analogue scale with responses ranging from 0% to 100%, the median response was 50% (25th to 75th percentile; 31% to 62%).

In 1999, McAlister *et al.* published a similar paper describing the attitudes of Canadian general internists towards research evidence and barriers they face in using research evidence.[39]

The authors developed their study instrument based upon other published questionnaires[46-48] and undertook pilot testing with their intended population to ensure face validity. The questionnaire was mailed out to all members of the sampling frame, with two follow up mail outs to non-responders.

The sampling frame for the study was listed physician members of the Canadian Society of Internal Medicine. Only members currently involved in active patient care and residing in Canada were eligible for inclusion.

The questionnaire was returned by 56.8% (296/521) of the physicians selected in the study sample. Characteristics of responders were compared to general characteristics of all members of the Canadian Society of Internal Medicine, with no major differences found.

Respondents were split into two groups according to the levels of self-reported use of research evidence, with those who reported *often* or *always* using research evidence being

labelled *evidence-users* and those who reported *sometimes*, *rarely* or *never* being labelled as *evidence non-users*. According to this definition, 70.1% (206/294) of the respondents who answered the question *how often do you employ EBM in your clinical practice* were classified *evidence-users* and 29.9% (88/294) of respondents were *evidence non-users*.

Attitudes towards research evidence and barriers to using research evidence were collected using five-point Likert scales, with response options specific to individual questions. When asked to indicate their level of agreement with the statement *EBM helps clinical decision making*, 90% (186/206) of evidence-users selected agree or strongly agree as compared to 76% (67/294) of evidence non-users (P<0.01). Evidence-users were also more likely to agree or strongly agree that *EBM improves patient outcomes* as compared to evidence non-users (62% vs. 42%, P<0.01).

Young and colleagues reported on the attitudes and knowledge of Australian general practitioners towards research evidence and the barriers faced in using research evidence to guide clinical practice.[35] Based on the questions of McColl *et al.*[34] a self-administered questionnaire was developed for use in this study. Face-to-face interviews were also conducted to provide additional qualitative data. A convenience sample of 60 general practitioners was asked to complete the study questionnaire, with a response rate of 100% (60/60).

When asked to indicate on a visual analogue scale their *own attitude towards EBM*, on a scale of "0" representing extremely cynical to "100" representing extremely positive the median score reported was 75. Yet when asked to indicate how they would *describe their colleagues' attitudes towards EBM* on the same scale, a median score of 50 was reported. In response to the question, the *day to day management of patients EBM appears to be useful* to respondents, where the score "0" represented completely useless and "100" represented extremely useful, a median score of 70 was reported. When asked to indicate *how much of*

their practice is based on research evidence respondents reported 70% of their practice to be based on research evidence.

Askew and colleagues conducted a study in order to describe attitudes towards research among Queensland general practitioners.[40] They designed a questionnaire mail out survey based upon the instruments developed and published by McColl *et al.* and Young *et al.,* with additional questions developed by themselves.[34,35]

The survey sample was obtained from the registration lists of general practitioners practicing in four out of the 20 Queensland Divisions of General Practice. The survey package was mailed out to 656 general practitioners with two follow up reminders sent in an attempt to maximise response rates. Responses were received from 75% (492/656) of the sample population.

Respondents were asked to indicate their agreement with several attitude statements concerning research evidence, with 70% (325/465) agreeing that *practising evidence-based medicine improves patient care*. When asked if *research is useful in day-to-day management of patients*, 84% (389/463) of those who answered this question were in agreement.

However, despite positive attitudes towards research, clinical expertise was valued over research evidence for clinical decision making: 78% (363/464) of respondents agreed with the statement that *they prefer clinical experience to research evidence when making clinical decisions*.

In 2006 Sur and colleagues published a web-based survey, supported by the American Urology Association, that explored the attitudes of members of the American Urological Association towards research evidence and to document barriers faced in using research evidence in practice.[43] They developed a survey instrument based upon the widely utilised survey of McColl and colleagues.[34]

Sur *et al.* obtained their study sampling frame by contacting all American Urological Association members with a listed e-mail address. These members were invited to participate in the web-based survey that was open for four weeks for completion. Follow up reminder e-mails were not sent, however the e-mail invitation did include a cover letter from the Chair of the American Urological Association to provide legitimacy for the study. The study was pilot tested in print format and then revised to suit a web-based format.

The sampling frame included 9,319 American Urological Association members who were e-mailed the study invitation, 724 responses were received resulting in a response rate of 7.8% (724/9,319). Characteristics of respondents were compared to characteristics of all members of the American Urological Association with no major differences reported.

The participants responding to the survey reported strong positive attitudes towards research evidence. When asked to rank their level of agreement using a visual analogue scale from one (completely disagree) to ten (completely agree) a median score of nine was given to the statement *EBM improves patient care* and a median score of eight was given to the statement *Surgical outcomes are improved by applying EBM.* When asked to rank their own use of research evidence, there was a higher self-reported level of use with a median score of eight given to the statements *all your medical decisions incorporate EBM* and *all your surgical therapy decisions incorporate EBM* whereas a median score of five was given to the statement *all urologists in your community utilise EBM.*

Following on from the web-based survey published in 2006 by Sur *et al.*,[43] Dahm *et al.* conducted a second study through the American Urology Association Office of Education to identify needs for future planning of educational activities surrounding the use of research evidence.[44] This second survey was based on the initial instrument used in the 2006 project published by Sur *et al.*, with additional new questions also developed.

The study sample was obtained by selecting a random sample of 2,000 Urologists from the sampling frame of 7,000 American Urological Association members recorded as practising in the United States. All participants were mailed a copy of the survey with a pre-addressed coded envelope to enable tracking of responses. Strategies were employed to maximise response rates including follow up e-mail reminders and re-sending of survey packages to non-responders. Anonymity of respondents was maintained with responses de-identified at entry into the study database. A response rate of 44.5% (889/2,000) was achieved for this study. Attitudes to research evidence were generally positive amongst the American Urology Association members responding to this survey.

Through the use of a visual analogue scale respondents indicated their level of agreement on a scale from one (completely disagree) to ten (completely agree) with a series of statements. With a median score of nine, respondents agreed with the statement *the use of current best evidence guidelines improves the quality of health care* and with a median score of eight, respondents agreed with the statement *practicing EBM improves patient care.* The statement *most of your surgical decisions incorporate EBM* also received a median score of nine, whilst a median score of eight was given to the statement *most of your medical therapy decisions incorporate EBM.* Agreement with the statement that *all urologists in your community utilise EBM* was low, with a median score of four.

Surgeons also report positive attitudes towards the use of research evidence to support clinical decisions. In 2007 Kitto *et al.* published the results of a study that investigated the attitudes of Australian surgeons towards the use of research evidence in practice.[41]

A self-administered mail out questionnaire was developed, and the sampling frame for the study was the current list of practicing surgeons within Southern Health in the Victorian Metropolitan Health Service. All 50 listed surgeons were sent the questionnaire, with a response rate of 50% (25/50).

Surgeons were asked to rate their agreement with various statements regarding research evidence use. Their responses were captured using a five-point Likert scale, where one represented *strongly agree* and five represented *strongly disagree*. A mean score below 2.5 therefore indicated *agreement* whereas a score above 2.5 indicated *disagreement*. The respondents indicated disagreement with the negative statements, *EBM is a form of 'cook-book' medicine* and *EBM is a fad,* registering means scores of 3.0 and 3.1 respectively. Surgeons indicated agreement with the positive statement *EBM is mainly concerned with patient outcomes,* with a mean score of 1.9 (SD 0.70).

Positive attitudes may not correlate with appropriate use behaviours

The attitudes of Dutch Orthopaedic Surgeons towards research evidence and use of research evidence were reported in a paper published by Poolman *et al.* in 2007.[42] The authors developed a Dutch language questionnaire utilising the instrument developed by McColl and colleagues.[34] Their questionnaire was pre-tested and validated with adjustments made following each set of testing.

The study involved a direct mail out to all listed members of the Dutch Orthopaedic Association. Potential respondents were assured their responses would remain confidential and anonymous. Response rates were maximised through promotion at Association meetings, provision of a pre-paid coded return envelope and repeat mail outs to non-responders.

Sixty percent (367/611) of the surgeons who were sent the study package returned their questionnaire. Characteristics of respondents were compared to a random sample of non-responding members of the Dutch Orthopaedic Association, with no major differences noted.

Attitudes towards research evidence were positive amongst the respondents. When asked to indicate on a visual analogue scale with scores ranging from zero (strongly disagree) to 100 (strongly agree), their level of agreement with the statement *practicing evidence-based medicine improves patient care* scored 75 (25th to 75th percentile, 63 to 84). When

respondents were asked to indicate *how useful are research findings in your day to day management of patients* on a visual analogue scale from 0 (extremely useless) to 100 (extremely useful), a median score of 74 (25th to 75th percentile, 65 to 83) was reported.

Despite positive attitudes toward improving patient care and usefulness, *proportional use* of research evidence rated lower: When asked to indicate *what percentage of your daily practice is evidence based* on a visual analogue scale from zero to 100%, the median score was 52% (25th to 75th percentile, 33%-67%).

In 2009, De Vito and colleagues conducted a landmark study that also investigated this concept of 'proportional use'.[45] These authors investigated knowledge, attitudes and *appropriate use* of RCTs and meta-analyses by Italian physicians. In order to achieve this objective, they developed and evaluated a metric of *appropriate use* that was defined as *reading and using the results of RCT's and meta-analyses in clinical practice at least sometimes*.

The authors developed a self-administered mail out survey to be sent to a group of randomly selected Italian physicians, with repeat mail outs and telephone calls to non-responders. Potential participants were assured that all replies would be anonymous.

The study sample was obtained through the use of registration lists from the Board of Physicians in two regions of Italy, which included a total of 47,137 physicians. Only currently practising physicians were eligible for inclusion in the study.

The survey was pilot tested and revised to ensure it was practical, valid and easily interpretable. The authors conducted a sample size calculation to ensure adequate power was achieved and serial mail-outs were conducted.

The survey was mailed out to 933 Italian physicians, with 654 responses giving an overall response rate of 70.1% (654/933). The authors addressed the issue of potential bias

through identification and comparison of characteristics of responders to non-responders, with no differences reported.

Italian physicians responding to this survey demonstrated positive attitudes towards using research evidence to guide clinical decision making, with 58.9% (364/618) agreeing that the *application of results of RCTs and meta-analyses improve the health status of patients*. Whilst 62.9% (390/620) of respondents agreed that *meta-analysis is a useful tool to help physicians to select effective health interventions,* 61.1% (379/620) of respondents agreed with the statement *many decisions in clinical practice cannot be based on the results of RCTs and meta-analysis but rather on the individual patient needs.*

Despite generally positive attitudes towards the use of research evidence to guide clinical practice decisions, only 32.1% (95% CI, 28.5 to 35.6) of 654 respondents could be classified as appropriate users, defined *as reading and using the results of RCT's and meta-analyses in their clinical practice at least sometimes*.

Attitudes and use amongst intensive care clinicians

An extensive search of MEDLINE and EMBASE failed to yield any studies that had investigated attitudes of intensive care clinicians towards the use of research evidence to support clinical decision making.

Attitudes towards specific types of research evidence

The RCT is considered the most scientifically rigorous and objective type of primary experimental research design and is held up as the gold standard for comparing the relative benefits of competing health care interventions.[49] Clinicians appear to have a higher level of trust in RCTs and often regard them to be more useful than other types of research evidence.[35, 36, 44]

In a 2004 publication outlining a survey investigating the attitudes of Swiss surgeons towards the use of research evidence in clinical practice, the RCT was found to be trusted above all other types of evidence resources.[36]

The questionnaire instrument utilised in the study was designed by the authors, with pre-testing conducted prior to administration. Small gifts were offered as an incentive to encourage participation. The sampling frame for the study was all participants attending the 76th and 77th Annual *Arbeitsgemeinschaft für Osteosynthesefragen* course in Davos Switzerland.

The survey was delivered to 1,064 attendees at the course, with a response rate of 50. Respondents were predominantly male (84%) with a mean age of 44 years. Fifteen percent of respondents reported having completed research training in evidence based medicine.

Using a 5-point Likert scale with response options *definitely trust, probably trust, not sure, probably not trust* and *definitely not trust*, participants were asked to rate various evidence sources. The highest level of trust reported by respondents was with RCTs, with 90% of respondents reporting *definitely* or *probably trust*, compared to meta-analyses of randomised controlled trials where 81% reported *definitely* or *probably trust*.

In a survey of Australian general practitioners conducted in 2001, Young and colleagues also reported that respondents found original research articles more useful than all other evidence resources.[35]

In Young *et al.*'s questionnaire, based upon the work of McColl *et al.*,[34] 60 participating general practitioners were provided a list of nine evidence resources and asked to rate how useful they found them by selecting from the response options: *very useful, somewhat useful, not at all useful,* or *don't know*. The most highly rated resource was *original research articles published in peer-reviewed journals,* with 90% of the 60 responding general practitioners rating this resource as *very or somewhat useful. Evidence based clinical practice*

guidelines were rated as *very or somewhat useful* by 87% of respondents, followed by *journals that summarise recent important research evidence* which, was rated as *very or somewhat useful* by 79% of respondents. The lowest rated resource was *systematic reviews or meta-analyses, such as the Cochrane library* with just 48% of respondents rating this resource as *very or somewhat useful*.

Dahm *et al.'s* 2009 survey of members of the American Urological Association also reported that the most trusted evidence resource amongst respondents was the RCT.[44]

Respondents were presented with a list of seven evidence resources and asked to rank their trust in each using a five point Likert scale, with responses ranging from *definitely not trust* to *definitely trust*. From the 889 responding urologists, 97% reported that they *probably* or *definitely trust RCTs* and 85% of respondents also reporting that they *probably* or *definitely trust meta-analyses of RCTs*. The *case report* was the least trusted with 17% of respondents selecting *probably* or *definitely trust* in response to the question concerning this item.

Time to read and learn as a barrier

Clinicians report challenges with regards to keeping up to date when faced by the exponentially increasing volume of medical literature, with *time to read and learn* one the most frequently cited barriers to the incorporation of research evidence into clinical practice.[34, 35, 40] A report published by the United States (US) Institute of Medicine highlights the overwhelming volume of primary research clinicians are faced with reading in order to keep up to date with advances in medicine.[50]

The authors of the report conducted a search of PubMed for articles indexed in MEDLINE during each year from 1970 to 2010. In 1970, approximately 200,000 peer-reviewed journal publications were indexed. By the year 2010 the same search resulted in approximately 750,000 peer-reviewed publications, demonstrating the number of biomedical

and clinical research studies being published each year has nearly quadrupled over the last 40 years (see **Figure 3**).[50]

Figure 3. Number of journal articles published on health care topics per year from 1970 to 2010 (from US Institute of Medicine[50]).
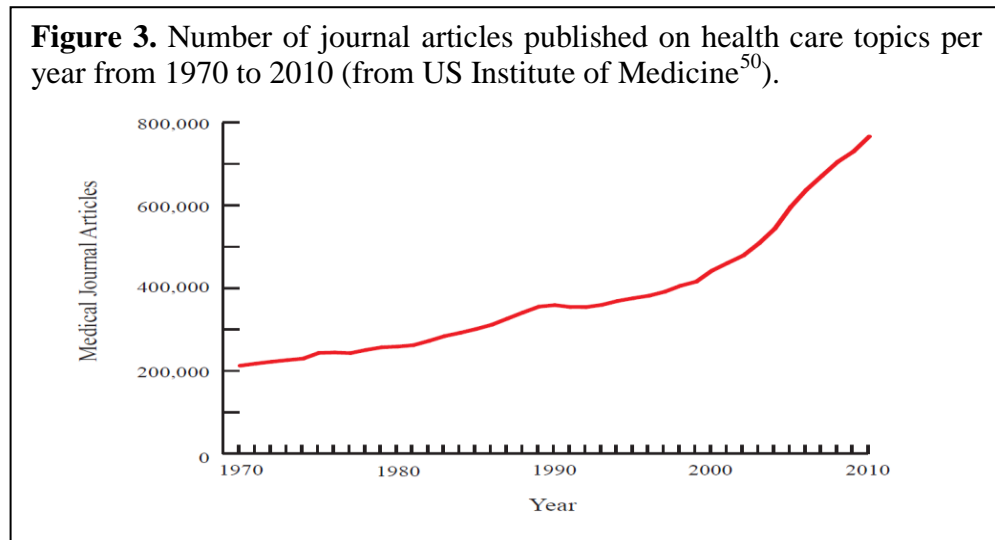
In 1998 McColl and colleagues completed their influential survey of general practitioner's attitudes towards research evidence.[34] Their survey was completed by 302 practicing general practitioners in the Wessex region of England. The investigators included a free-text section for respondents to answer the question "*what do you think are the major barriers to practising EBM in general practice?*" One investigator was responsible for reviewing the responses which were then coded and grouped according to themes. The item response rate to this question was 80% (242/306), with respondents able to indicate more than one barrier in their answer.

Lack of personal time was the most highly cited barrier with 71% of 242 respondents indicating this was a major barrier to incorporating the results of research evidence into their practice. The next most frequently reported responses were: *personal and organisational inertia* with 14%; *attitudes of colleagues* with 12%; *patients' expectations* with 10% and; *lack of hard evidence* with 8% (20/242).

In 2001, when Young and colleagues repeated McColl *et al.*'s[34] study in Australia, amongst the 60 general practitioners who completed their survey, three of the five most highly

ranked barriers to using research evidence in general practice were related to aspects of time.[35] *I do not have time to read and appraise research articles* was selected as a *very important barrier* by 40% (24/56) of respondents, whilst only 18% (11/56) of respondents indicated this was *not* a barrier. Twenty-eight percent (17/56) of respondents ranked *I do not have the time to search for evidence* as a *very important* barrier and 25% (15/56) indicated that *having the time to discuss the implications of available evidence to patients during routing consultations* was also a *very important* barrier.

Time was also reported as a barrier in a study published by Askew and colleagues in 2002.[40] The study involved a survey of 492 Queensland general practitioners, which was followed up with semi-qualitative interviews to explore barriers to research use with a convenience sample of 18 general practitioners selected from the original sample of 492. The interviews were transcribed verbatim, with data analysed using qualitative data analysis software to identify recurrent patterns and themes. *Time as a barrier* was noted as a recurring theme from the interviews. When prompted to speak of issues related to the use of research evidence in their clinical practice, general practitioners spoke of "*a major negative and it's tied in with time.*" The general practitioners described a "*lack of remuneration for anything that does not involve patient contact, meaning that reading and incorporating research into the day becomes something of a luxury that can not be afforded.*"

Responses from Dutch orthopaedic surgeons suggest that whilst time is a concern for some, there is a wide variation in how time pressure is felt. Published in 2007, Poolman and colleagues surveyed 367 members of the Dutch orthopaedic association.[42] Respondents were asked to rate on a visual analogue scale (with zero representing *strongly disagree* and 100 representing *strongly agree)* a number of statements regarding evidence use. When asked to rate the statement *the adoption of EBM, however worthwhile as an ideal, places another demand on already overloaded orthopaedic surgeons* respondents recorded a median score of

53 (25th to 75th percentile, 31 to 73). However, with a range in rankings from zero to 100, it was apparent that the responding surgeons had widely different opinions regarding this statement.

In a study of Australian and New Zealand radiation oncologists and registrars, from the 191 participants who responded to the survey, almost half (49.7%) of the respondents reported that *the whole medical information explosion is overwhelming.*[51] Doctors with less clinical experience were more likely to select this response, with significantly more registrars than radiation oncologists agreeing with this statement (62.2% vs 44.9%; $\chi^2 = 5.19$, P=0.02).

Interestingly, some groups of doctors do not rank time pressure as a major concern. Kito *et al.*'s 2007 survey of practicing surgeons from Southern Health in Victoria did not find time pressure to be an important barrier to using research to guide their clinical decision making.[41] Using a Likert scale graduated from a score of one indicating *very important* to five indicating *not very important,* respondents ranked a number of potential barriers. For the statement *I do not have the time to read and appraise,* the mean score reported was 3.7 given for primary articles, 4.0 for systematic reviews, and 4.0 for clinical practice guidelines. For the statement *I do not have time to search for resource studies* the mean score reported was 3.5 for primary articles, 3.5 for systematic reviews, and 3.6 for clinical practice guidelines. All of the above mean responses to questions related to time pressure barriers higher than the Likert scale's neutral score of 2.5, thus each item response tends towards the *not important* side of the scale.

Technical knowledge as a barrier

A lack of knowledge with regards to the technical issues surrounding the conduct and appraisal of research evidence has been proposed as a barrier to the appropriate use of research evidence in clinical practice. Technical knowledge amongst clinicians has been measured within numerous surveys on research use, with extremely variable results.[34-36, 42]

McColl *et al.*'s 1998 study of general practitioners included a section to determine the levels of knowledge amongst the survey participants.[34] The 302 general practitioners responding to this section were asked to indicate their own level of understanding of ten technical terms and rate them using the following scale: *understand and could explain, some understanding, don't understand but would like to,* or *it would not be helpful for me to understand*.

The highest level of understanding was reported for the term *number needed to treat* with 35% (102/288) of those who answered this question indicating they *understand and could explain to others.* The lowest score was achieved for the term *odds ratio* with only 11% (31/289) indicating that they *understand and could explain to others.*

In Young and colleagues 2001 survey of Australian general practitioners, respondents were presented with 14 technical terms.[35] They were asked to indicate their level of understanding of these terms using the same scale used by McColl *et al*:[34] *I could understand and explain to others, I already have some understanding, I don't understand but would like to,* and *would not be helpful for me to understand.*[34] The term 'randomised controlled trial' was the most understood, with 38% (23/60) indicating they *understand and could explain to others* and 42% (25/60) indicating they *have some understanding* of the term. With regards to the lowest rated terms 'systematic review' and 'meta-analysis', only 18% (11/57) of respondents reported they *understand and could explain to others* the term 'systematic review' and 15% (9/57) of respondents reported they *understand and could explain to others* the term 'meta-analysis'.

In Hanson *et al.*'s 2004 survey of Swiss surgeons, the investigators also measured respondents' level of knowledge of key principles in critical appraisal.[36] In this study, whilst respondents were able to correctly identify simple technical terms, they were less able to correctly identify more complex concepts.

Using a five point Likert scale with response options *definitely acceptable*, *probably acceptable*, *not sure*, *probably not acceptable* and *definitely not acceptable*, participants were asked to indicate their understanding of technical issues related to randomisation, allocation concealment and blinding. Ninety-five percent (505/532) of respondents were able to correctly identify (*definitely* or *probably acceptable*) appropriate methods of randomisation such as the use of a *computerised randomisation schedule* or a *random numbers table*. They were also able to correctly identify *inappropriate* methods of randomisation, with *patient preference* rated as *definitely* or *probably acceptable* by only four percent (21/532) of respondents.

When questioned on technical aspects of allocation concealment, respondents were able to correctly identify that the use of *opaque envelopes* containing the next treatment allocation is an acceptable method, with 79% (421/532) selecting *definitely* or *probably acceptable*. However, respondents were not able to correctly identify *inappropriate* methods of allocation concealment. Forty-nine percent (252/532) of respondents incorrectly believed that it was acceptable (*definitely* or *probably)* or were *unsure* if it was acceptable *to disclose the full randomisation schedule and treatment allocation of the next patient* before the patient was enrolled and consented. Awareness of other methods of reducing bias in research was low, with 21% (114/532) of respondents indicating they had *never heard* of the term 'blinding'.

In Poolman *et al.*'s 2007 study involving 367 Dutch orthopaedic surgeons, knowledge regarding ten methodological terms was also assessed using the rating scale of McColl *et al.*[34, 42] In this study, the highest rating for understanding was reported for the term 'systematic review', with 92.8% (333/359) of respondents indicating that they either *understand and could explain to others* or *had some understanding.* The term with the lowest level of

understanding was 'odds ratio', with 60.7% (218/359) of respondents indicating that they either *understand and could explain to others* or *had some understanding.*

De Vito *et al.* also attempted to assess knowledge in their 2009 study of Italian physicians.[45] In this study, knowledge was tested with a series of true or false statements about RCTs and meta-analyses, with responses collected using three-point Likert scales providing the options *agree*, *uncertain* or *disagree*.

For the true statement *meta-analyses combines the results of different individual studies with the purpose of integrating the findings,* 71.4% (442/619) of the respondents agreed and correctly identified the statement as true. With regards to a more complex true statement regarding relative risk and odds ratios (*relative risk and odds ratio are measures used in RCTs and meta-analyses to quantify the effect of health interventions),* 50.8% (307/604) of respondents agreed and correctly identified the statement as true.

Reducing evidence-practice gaps

Many strategies and interventions have been proposed for reducing the gap between medical knowledge and medical practice. Interventions range from formal theoretical frameworks that introduce complexity by proposing *hierarchies* of research evidence,[52-57] to the use of simple summary tools that reduce complexity through the efficient and explicit presentation of research evidence.[58] Other initiatives have resulted in the development of unique informatics resources such as the Cochrane Library,[59] and the production of focussed reminder tools, such as pocket cards and posters.[60] Unfortunately, a recent Cochrane review highlights a problem in this area, with their conclusion that the "low quality of the studies in this area provides insufficient evidence to determine with certainty which interventions are most effective" at closing evidence-practice gaps.[61]

The purpose of this section is to provide an overview of key strategies and interventions that are often used in clinical medicine.

Hierarchies of evidence

Various *hierarchies of evidence* have been proposed by different authoritative bodies as a strategy to improve evidence uptake and reduce evidence-practice gaps. A *hierarchy of evidence* ranks different sources of knowledge from *most reliable* to *least reliable* and thus aids clinicians by encouraging them to make effective use of the *best available research evidence*. Unfortunately there is no one universally accepted hierarchy of evidence.

Whilst most hierarchies rank *systematic reviews of RCTs* at the top as the 'most reliable information source, some theoretical frameworks propose that *electronic repositories of simple evidence summaries* should rank even higher than primary research publications.[52-57] The Oxford Centre for Evidence Based Medicine *2011 Levels of Evidence* document provides a hierarchy for *best evidence* available to clinicians when answering clinical questions.[53] For example, to address the clinical question "does this intervention help patients?", the *2011 Levels of Evidence* document ranks systematic reviews of RCTs at the top (Level 1), followed by four subsequent levels: Level 2) RCTs or observational studies with strong effects; Level 3) non-randomized controlled cohorts / follow-up studies; Level 4) case-series or case-control studies or historically controlled studies and; Level 5) mechanism-based reasoning

Within Australia, the *NHMRC Evidence Hierarchy* also classifies systematic reviews of RCTs as Level I evidence, however the five subsequent levels of evidence differ from the Oxford approach.[52] The NHMRC defined subsequent levels of evidence are: Level II) an RCT; Level III-1) a pseudo-randomised controlled trial; Level III-2) a comparative study with concurrent controls; Level III-3) a comparative study with historical controls and; Level IV) a case series with either post-test or pre-test/post-test outcomes.

In 2001 Haynes *et al.* published the *4S* hierarchical model.[54] With time constraints consistently reported by clinicians as a barrier to using research evidence uptake,[34, 35, 40] Haynes *et al.*'s model placed *electronic repositories of evidence summaries* (e.g. the Database

of Abstracts of Reviews of Effects) towards the top of the hierarchy (See **Figure 4**).

Interestingly, the 4S hierarchy places original publications of RCTs at the *bottom* of the

hierarchy.

Figure 4. The 4S evidence hierarchy (from Haynes *et al.*[54]).
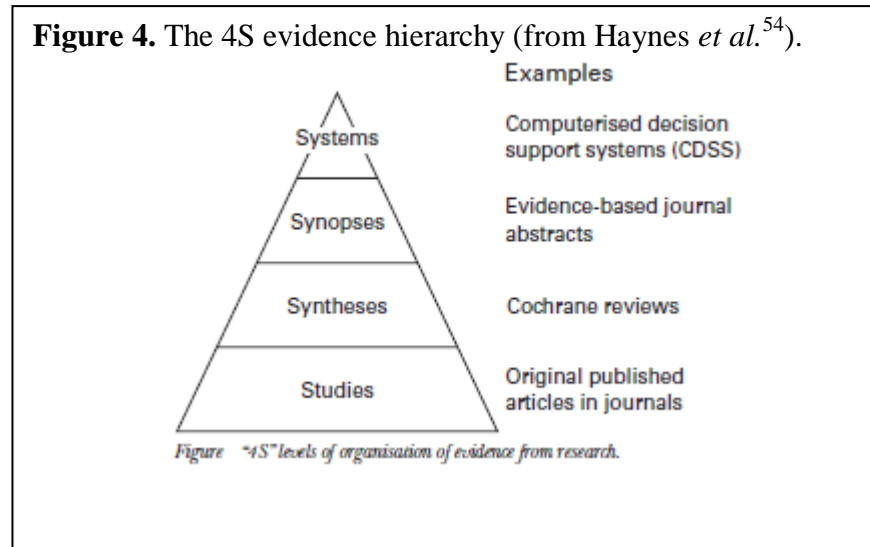
Haynes *et al.* have updated and extended the *4S* model three times, in 2006, 2009, and

in 2016, with the final update renaming the framework the *Evidence Based Healthcare*

Pyramid 5.0.[55-57] The theoretical framework was modified during these three updates to

include *emerging evidence resources* and to more clearly explain the importance of *evidence-*

summary documents. The purpose of an *evidence summary document* is to overcome time-

related barriers to the use of primary research studies by presenting key aspects of a

systematic review in a much briefer format. Each update by Haynes *et al.* has seen *evidence*

summary document resources consistently placed above systematic reviews and RCTs in the

evidence hierarchy. Interestingly, there have been no formal evaluations of the impact this

theoretical construct has on evidence-practice gaps.

 Systematic Reviews and Meta-analyses

The *systematic review* is a summary tool that provides clinicians with an objective

appraisal and assessment of a series of related primary research studies on a focussed clinical

topic.[49] In contrast to a traditional *narrative review*, the systematic review utilises rigorous,

systematic, and transparent methods to minimize bias in its conclusions.[54-56] *Meta-analysis* is

a statistical procedure for mathematically combining the estimates of treatment effect

obtained from the individual clinical trials included in a systematic review.[49]

The conduct of a *systematic review* requires a significant amount of time and resources

to identify, retrieve, appraise and integrate *all published studies* on a focussed clinical

question.[62] *Systematic reviews* are advantageous to the time pressured clinician as they

provide a pre-appraised summary of the best available evidence on a topic.[56,63]

The *systematic review* evolved in the 1970s to become a more formal method of

summarising the results of clinical trials.[64,65] Recognising the potential importance of the well

conducted systematic review, a group of health care researchers from Oxford came together to

develop a uniform set of methods for conducting systematic reviews. Eventually calling

themselves *The Cochrane Group*, this early initiative "*to promote evidence-informed health

decision-making by producing high-quality, relevant, accessible systematic reviews and other

synthesized research evidence*" has met with great success.[66] *The Cochrane Database*

currently contains over 7,000 systematic reviews with access provided to clinicians via

government subscriptions in many countries.[67]

Despite the proposed time saving advantages of systematic reviews and meta-analyses,

clinicians consistently rank them below RCTs as a preferred evidence source.[34, 35, 39, 45]

McColl *et al.*'s 1998 survey of general practitioners questioned participants on their

awareness and use of various evidence based resources. When asked to indicate whether they

used the Cochrane Database of Systematic Reviews, 60% (169/284) of the respondents were

unaware of the Cochrane Database and only 4% (11/284) reported that they actually *use*

Cochrane Reviews to help in clinical decision making.[34] Similarly, in 2001 Young and

colleagues reported that only 15% (9/60) of Australian general practitioners rated Cochrane

Library systematic reviews or meta-analyses as *very useful*.[35] McAlister *et al.*'s 1999 survey

of physician members of the Canadian Society of Internal Medicine produced similar results, with only 5% (15/294) of respondents reporting that they *frequently used* Cochrane Collaboration Reviews as an information source. In this survey, *clinical experience* and *the opinion of colleagues* were both used as an information source more frequently than Cochrane Reviews.[39]

Published in 2006, Sur *et al.* asked members of the American Urological Association about their awareness of various evidence resources.[43] Of the 700 Urologists who completed their survey, 54% reported that they were *unaware* of the Cochrane Database of Systematic Reviews, with only 7% (49/700) of respondents reporting that they *used Cochrane reviews regularly in their decision making process.* In a follow up study published by Dahm *et al.* in 2009, American Urology Association members reported a similarly low awareness of the Cochrane Database of Systematic Reviews, with 76% (676/889) of respondents reporting they were *unaware* of its existence, whilst just 8% (71/889) reported they had *ever used it*.[44]

Similar levels of awareness and frequency of use are reported in a survey of Danish doctors published in 2004.[68] In this study conducted in a Copenhagen hospital, *the Cochrane Library* was the least frequently used information resource, with 49% (90/183) of respondents stating they had *never used it* and just 9.3% (17/183) reporting *frequent* use. Traditional information resources including *textbooks* and *colleagues* were the most frequently used, with 67% (143/213) of respondents reporting using textbooks *frequently* and 65% (135/208) reporting using colleagues' advice *frequently*. These patterns of use are similar to the results reported by studies conducted in Australia and New Zealand.

In 2003, Veness *et al.* published the results of a survey of radiation oncologists practicing in Australian and New Zealand.[51] When asked to describe their familiarity with the Cochrane Library, 18% of the 189 respondents reported they were *unaware* of its existence. A

further 52.4% (100/189) reported were *aware of it but did not use it*, whilst 8.4% (16/189) reported that they *used it to help in clinical decision making*.[51]

Clinical Practice Guidelines

An extremely ambitious and forward thinking initiative to improve health care practice by disseminating knowledge has arisen from a contractual relationship formed by the US government's Agency for Healthcare Research and Quality with the US Institute of Medicine. After a thorough study of the problems arising due to the exponential growth in the number of original research papers published each year in the field of medicine, the Institute of Medicine formally recognised the fundamental importance of "critically appraised and synthesized scientific evidence" resources.[69] Furthermore, they acknowledged that as a medium for the promotion of "critically appraised and synthesized scientific evidence" *rigorously developed clinical practice guidelines* "have the power to translate the complexity of scientific research findings into recommendations for clinical practice and potentially enhance health care quality and outcomes. However, the current state of Clinical Practice Guideline (CPG) development has yet to meet this potential."[69] In order to capture defining characteristics that will allow clinical practice guidelines to achieve their full potential for practice change, the Institute of Medicine developed and promoted a new definition: "Clinical practice guidelines are statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options."[69]

Rigorously developed clinical practice guidelines systematically review and grade the primary research evidence on a topic and then provide expert recommendations for implementation in clinical practice to aid clinicians in determining how and when to use the evidence.[69] Clinical practice guidelines are advocated as a strategy to improve the quality and consistency of care provided by closing evidence-practice gaps.[70]

Do guidelines guide practice?

Dating back to 1977, multiple clinical practice guidelines have promoted treatment recommendations for the management of hypertension based on the results of numerous clinical trials.[71-73,74] The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure has published eight updates to their original guideline, with the most recent update published in 2014.[75]

The 2014 Joint National Committee guideline was developed by 48 panel members with expertise in hypertension, primary care, cardiology, clinical trials, research methodology and guideline development and implementation selected from over 400 volunteers who self-nominated for participation. A literature search was conducted to identify RCTs focusing on adults aged 18 years or over with hypertension and included studies with the following pre-specified subgroups: diabetes, coronary artery disease, peripheral artery disease, heart failure, previous stroke, chronic kidney disease (CKD), proteinuria, older adults, men and women, racial and ethnic groups, and smokers. Studies that included less than 100 persons or did not have a follow up period of at least one year were excluded from the review. The search was conducted in PubMed and CINAHL, with the full search strategy included in a supplementary document to the primary publication. An external methodology team reviewed the quality of included trials and summarised data into evidence tables. The panel was then responsible for developing clinical recommendations and grading the strength of each recommendation upon the quality of research evidence presented.

A *Strong - Grade A recommendation* was made for the use of pharmacological treatment in adults aged 60 years who have a systolic blood pressure of 150 mmHg or higher, or diastolic blood pressure of 90 mmHg or higher to achieve a target goal of a systolic blood pressure lower than 150 mmHg or a goal of a diastolic blood pressure lower than 90 mmHg. A *Strong – Grade A recommendation* is the highest level of recommendation according to the

grading system used in the guideline, and indicates that there is high certainty based on research evidence that the net benefit is substantial.[75]

Despite incorporation of similar recommendations for similar treatment thresholds and treatment targets in multiple major international guidelines, a recent report from the US highlights an evidence-practice gap resulting from *underuse* of these recommendations for the treatment of hypertension.[76] Utilising data from the most recent National Health and Nutrition Examination Survey, the American Heart Association estimated that 32.6% of adults in the US have hypertension. Of those patients with documented hypertension, 23.5% did not receive any treatment for their blood pressure, whilst 45.9% of treated patients did not achieve appropriate treatment targets for their systolic or diastolic blood pressures.

In 1994 Grilli and colleagues published a review of 23 individual studies documenting evidence-practice gaps in 143 guideline-based clinical recommendations.[77] They found a relationship between the *complexity* of a guideline and the adherence to recommendations within the guidelines, with evidence-practice gaps significantly higher with more complex guidelines.

Grilli *et al.* conducted a literature search to identify papers published in the English language between 1980 and 1991. Studies that reported evidence-practice gaps in clinical practice guidelines developed by official medical professional organisations, task forces or government agencies were eligible for inclusion. The search was conducted in the MEDLINE database, with reference lists of relevant reviews and bibliographies also searched and personal contacts utilised.

Evidence-practice gaps were measured by assessing adherence to guideline recommendations. Adherence was defined as either the proportion of physicians acting according to the recommendations in the guideline, or the proportion of patients treated

according to the recommendations in the guideline. Adherence to guideline recommendations from individual studies were extracted according to these definitions.

The investigators assessed three pre-determined characteristics that they believed influenced the uptake of clinical recommendations made by clinical practice guidelines: *complexity*; *trialability*; and *observability*. *Complexity* referred to whether a practitioner with usual training and skills, working in an average setting: a) perceived it to be difficult to learn or understand the clinical intervention; or b) had no control over the resources required for implementation. *Trialability* referred to whether a practitioner with usual training and skills, working in an average setting, was able to experiment with the clinical intervention. *Observability* referred to whether a practitioner with usual training and skills, working in an average setting, was able to obtain timely feedback on any impact of the intervention on patients' outcomes. Recommendations within the guidelines in the included studies were classified independently by the investigators as high or low for each of these three pre-determined categories.

The literature search resulted in the identification of 47 potential studies that investigated adherence to guideline recommendations. Twenty-three guideline studies met the full inclusion criteria. These studies contained 143 individual recommendations for practice that addressed 70 different aspects of medical care. Adherence to recommendations within the guidelines in the included studies was assessed using chart audit data for 54% (77/143) of the recommendations, with a further 37% (53/143) assessed based on physician self-reporting, and 9% (13/143) assessed using administrative data. Adherence to guideline recommendations in the included studies was measured for a mean time interval of 2.9 years (range 1 to 9 years).

Overall, major evidence-practice gaps existed for all the treatment recommendations, with 54.5% (95% CI, 50.2 to 58.9) of treatments delivered consistent with the guideline

recommendations. The magnitude of evidence-practice gaps differed by clinical area (P<0.001), with guideline compliant treatment highest in cardiac (63.6%) and cancer patients' management (62.5%), and lowest in preventative care (46.2%), dental care (45.8%) and obstetrics and gynaecology (43.3%).

An analysis of the classification of clinical recommendations according to the pre-determined characteristics of complexity, trialability and observability demonstrated that there was significantly lower compliance (P=0.05) with recommendations that were *highly complex* (41.9%) compared to those that were judged to have *low complexity* (55.9%). There was also a significantly higher (P=0.03) compliance with recommendations that were judged to have *high* (easy) *trialability* (55.6%) compared to recommendations that had *low trialability* (36.8%). High versus low observability of the recommendation did not, however, demonstrate any significant difference in compliance rate (54.6% versus 52.4%).

These findings of overall compliance rates reported by Grilli *et al.* are similar to the results obtained by Sur *et al.* in their 2006 survey of the American Urological Association members.[43] Although 98.9% of the 710 members who responded to the survey reported they were *aware of the American Urology Association Best Practice Guidelines*, just 45% (320/710) reported they *used the guidelines regularly in their decision making process.*

Clinician confidence in clinical practice guidelines

Despite clinical practice guidelines being tailored to meet clinicians' needs for critically appraised and synthesized scientific evidence, some clinicians may not have *confidence* in clinical practice guidelines.[41, 43]

In 2007 Kitto *et al.*[41] asked Australian surgeons to rate their *confidence* in various sources of information using a five-point Likert scale, where one represented *very confident* and five represented *not very confident*. The most highly rated source was *your own judgement* with a mean score of 1.9 (SD 0.6), followed by *information contained in*

bibliographic databases with a mean score of 2.0 (SD 1.0) and *textbooks* with a mean score of 2.1 (SD 0.5). In total, nine sources of evidence were rated. Of all nine sources, surgeons reported the least confidence in *clinical practice guidelines,* with a mean score of 3.2 (SD 4.0).

Methods for improving clinical practice guidelines

The ongoing existence of evidence-practice gaps has been identified as an issue in health care by organisations such as the National Institute of Clinical Studies in Australia.[11] Despite the promotion of clinical practice guidelines as a way to reduce evidence-practice gaps their success remains inconsistent. As such, there has been a notable increase over the last decade in the volume of research into methods to improve evidence uptake and close evidence-practice gaps.

Simple reminders

In 2003, Daucourt and colleagues published the results of a study investigating simple methods for supporting adherence to clinical practice guidelines for thyroid function testing.[78] These methods included the use of an educational *ordering form* and the use of educational *pocket reminder cards*.

The study was conducted in the region of Aquitaine in South-West France and included six hospitals who volunteered to participate. The hospitals included four general medical/surgical hospitals and two psychiatric hospitals, which ranged in size from 90 beds to 904 beds.

In preparation for the conduct of the study, the hospital's quality committee, a regional working group and a national review group collaborated to develop National clinical practice guidelines for thyroid function tests in adults. The study design was a two-by-two factorial cluster RCT. Prior to randomisation, hospitals were matched according to size and activity with two small hospitals matched (171 beds and 90 beds), two medium sized hospitals

matched (535 beds and 494 beds) and two psychiatric hospitals matched (904 beds and 541 beds). Within each pair, one hospital was then randomised using a random number table to receive *an educational ordering form* vs. control. Following this initial randomisation at the hospital level, wards within each hospital were then matched into pairs according to rates of thyroid function test ordering observed during a pilot study period. Within each pair, one ward was then randomly allocated using a random number table to receive *educational pocket cards* vs. control.

At the end of the randomisation process, the authors reported the trial results in four distinct groups: 1) a dual intervention group who received the educational thyroid function test ordering form *and* the educational pocket card; 2) an ordering form intervention group; 3) a pocket card intervention group and; 4) a control group receiving neither intervention.

The characteristics of the four groups differed significantly following randomisation. There was a higher proportion of women in the pocket card intervention group (73%) compared to the other groups (65% in dual intervention group; 63% in the ordering form intervention group; and 61% in the control group, P<0.01).

Guideline conformity rate was calculated by evaluating the indication for ordering of each test against the recommendations in the guideline. An indication was not given for 3.7% (52/1,412) of tests in the study. Overall guideline conformity was 73.9% (1,005/1,360). When compared to the control group, the *ordering form* intervention group was the only group to demonstrate a significantly higher (P<0.0001) level of guideline conformity, with 82.6% (280/339) of tests ordered in accordance with recommendations compared to 62.0% (222/358) of tests ordered in accordance with recommendations from the guidelines in the control group. The results of this study demonstrate success with the use of an *order form* that acts as an educational reminder to improve adherence to recommendations within guidelines.

Printed guideline summary

A 2014 Canadian publication outlines the development of a dissemination strategy to support national diabetes clinical practice guidelines and investigate whether their dissemination strategy led to improved patient outcomes.[60]

The study was conducted in Ontario Canada and involved a mailed dissemination to general practitioners of the 1998 update of the Canadian Diabetes Association national clinical practice guidelines for diabetes. A targeted cardiovascular disease educational toolkit was developed to support the guideline dissemination. The toolkit contained *printed educational materials* including a summary of sections of the guidelines relevant to general practitioners; a four page outline of the key elements in the guideline addressing cardiovascular risk; a small laminated cardiovascular disease risk assessment pocket card; and a patient information leaflet with a risk self-assessment tool and list of risk reduction strategies.

The study was a pragmatic randomised controlled trial, with randomisation of the intervention at the level of the physician's practice location. Using a computer generated randomisation sequence *all* general practitioners practicing in Ontario were randomised according to their practice location, therefore ensuring all physicians practicing at a single location would be allocated to the same group. The intervention group were mailed the updated guidelines and the cardiovascular disease educational toolkit in June 2009, while the control arm only received the guidelines at this time.

The first part of the study involved the assessment of population based administrative data from the Ontario Ministry for Health recorded from July 2009 and April 2010 to measure rates of death and non-fatal myocardial infarction. All residents of Ontario aged 40 years and over who were diagnosed with diabetes as of July 1st 2009 were identified and grouped

according to which group their general practitioner had been randomised to. If they did not have a nominated general practitioner they were excluded.

The final study population included 933,789 patients with diabetes living in Ontario. A total of 4,007 family practice locations were randomised into the study, however the total number of general practitioners involved is unclear. The baseline characteristics of both patients and practices were similar in both groups. According to data retrieved from the Ontario Diabetes Database, 2.5% (11,736/467,713) of patients cared for by physicians who received the intervention died or experienced a non-fatal myocardial infarction during the study period. The control group death and non-fatal myocardial infarction rate was also 2.5% (11,536/466,076) demonstrating that the intervention had no effect on these patient oriented outcomes.

A second sub-study involved the collection of patient data from a group of randomly selected practices to assess the implementation of strategies aimed at cardiovascular risk reduction. Practices were selected from the primary intervention and control groups who received the initial guideline mail out, with 373 intervention practices approached and 395 control practices approached. One physician per practice was randomly selected and contacted to request participation in the study. Participation was voluntary, with a total of 40 physicians from each group included in the final sample. Records of a random selection of 20 diabetic patients cared for by each physician during the study period were examined to collect data on treatments initiated by the physician targeted at cardiovascular risk reduction as per recommendations from the guidelines. There was no significant difference in the primary outcome of prescribing rates of statin medications in the intervention and control groups. Unexpectedly the patients in the intervention group were significantly less likely (P=0.04) to achieve clinical practice guideline recommended blood pressure control targets, with 52.8% (420/795) of patients achieving a blood pressure less than the 130/80 mmHg compared to

63.5% (506/797) in the control group. There were no other significant differences in the rates of other clinical interventions initiated at the physician level.

This large population based study failed to find any benefit from the use of printed educational summary materials to improve guideline adherence.

Academic detailing

An early study demonstrating the benefits of *academic detailing* was conducted by Avorn and colleagues in 1983.[79] The term *academic detailing* is used to describe an educational intervention provided by a peer, one-on-one and face-to-face. In this study, *academic detailing* was provided to the physician-participants in their practice office by a clinical pharmacist. The pharmacists reviewed the printed guideline materials with the physician, outlined the research evidence supporting the treatment recommendations and presented clinical cases to generate discussion surrounding the physician's own clinical experiences.

The study was a randomised controlled trial conducted over a three year period. The investigators selected three drugs that they targeted their intervention towards. Medicaid prescribing records from 1979 were used to identify the study sample. Reimbursed prescriptions for the three target drugs in the areas of Arkansas, New Hampshire, Vermont and the District of Columbia were identified. From 5,555 prescriptions written in 1979 in the four study states, physicians who had written 20 or more prescriptions per year from each of two drug groups, or 30 or more prescriptions per year from any one group, were included in the study sample. This resulted in a sample of 435 physicians.

A randomised block method was used to allocate physicians to study groups. Physicians were initially divided into 12 blocks, balanced with equal numbers of physicians from each state in each block. Physicians in each block were then randomly allocated to one

of three groups; 1) a control no-intervention group; 2) a printed material intervention group and; 3) an academic detailing intervention group.

The prescribing patterns of the control group were recorded; however they were not exposed to any form of intervention. This provided a baseline of usual prescribing patterns during the study period for comparison. The *printed material intervention* group were separated into two subgroups. The *first subgroup* received in the mail a series of plain educational materials modelled upon a US Federal Drug Administration (FDA) drug bulletin. Three separate drug bulletins were mailed twice over a period of four months. The *second subgroup* received the same information that was contained in the drug bulletin presented in a series of *six colourful visually appealing documents*. The third study group was provided with face-to-face academic detailing in addition to printed education materials.

Medicaid data from January 1980 to December 1981 was used for the purpose of analysis in the study. There was a 4.6% loss to follow-up reported in the study, with 20 of the original 435 members of the study sample not included in the final analysis due to physician death, retirement and moving out of state.

The academic detailing intervention resulted in a significantly greater reduction in overprescribing compared with the other groups. Physicians in the academic detailing group prescribed an average of 782 less prescriptions per physician than those in the control group (P=0.001).This represents an absolute reduction in overprescribing of 15.2% compared to the control group.

Compared to the control group there was no significant difference in prescribing practices in the printed material group.

Opinion Leaders

In 2003, Berner *et al.* published the results of a study evaluating local *opinion leaders* in a standard quality improvement audit and feedback model. They found the formal

identification and inclusion of local *opinion leaders* improved adherence to treatment recommendations made in an unstable angina management clinical practice guideline.[80] An *opinion leader* is a local peer who is judged to be educationally influential.

The study was an RCT with hospitals assigned to one of three groups: 1) no intervention; 2) standard quality improvement model utilising audit and feedback or; 3) a local opinion leader driven intervention in addition to the standard quality improvement model utilising audit and feedback. It is unclear what process or sequence was used for randomisation, or whether allocation concealment was maintained.

A panel of experts selected five major quality indicators for measurement in the study from a national evidence based guideline for the care of unstable angina. The indicators included: the performance of an electrocardiogram within 20 minutes of arrival; receipt of aspirin or other antiplatelet therapy within 24 hours of admission; receipt of aspirin or other antiplatelet therapy at discharge; receipt of heparin during hospitalisation for patients at moderate to high risk for acute myocardial infarction or death and, receipt of beta-blockers during hospitalisation.

Only hospitals in Alabama with at least 100 or more patients whose medical records were classified with discharge diagnostic codes for 'unstable angina', 'angina pectoris', 'coronary artery disease' or 'chest pain unspecified' were eligible to participate in the study. From a total of 50 hospitals that met the eligibility criteria and were invited to participate, 22 hospitals agreed to be involved in the study. Medicare records for 1,076 patients were reviewed to obtain compliance rates with the five quality indicators during a designated baseline period. Following implementation of the study interventions, medical records were again reviewed to obtain compliance rates with the five quality indicators during a designated follow-up period.

In the hospitals randomised to the *opinion leader* intervention group, opinion leaders were identified and chosen through a peer nomination and selection process. All family practitioners, general internists, cardiologists and emergency physicians were sent a letter explaining the study and a peer nomination form asking them to identify potential education leaders relative to unstable angina. The opinion leaders with the most votes were selected and sent a recruitment letter. From eight identified and nominated opinion leaders, one withdrew following orientation and the other seven agreed to participate.

To support the quality improvement initiative, participating hospitals nominated an assigned quality improvement co-ordinator or project administrative contact to attend a half day orientation to the trial. This session provided a review of the unstable angina guidelines and presentation of blinded hospital-specific baseline compliance rates. Benchmarks of care were presented along with unblended feedback for their own hospital. In the opinion leader group hospitals, the opinion leader also attended these orientation sessions.

Opinion leaders were provided with additional education on the role of the opinion leader and a presentation of strategies that may be used to improve quality improvement activities including academic detailing, audit and feedback, standing orders, chart reminders and education. Educational materials were also provided including powerpoint slides, guideline indicator definitions, baseline feedback data and copies of the unstable angina guidelines.

Hospitals selected which of the five indicators they wished to target and then they were required to develop a quality improvement programme for their site which identified their targeted indicators.

The delivery of antiplatelet medication within 24 hours of arrival was the only measure in which compliance rates were significantly changed post intervention (opinion

leader group 20.2% increase in compliance vs. standard quality improvement group 3.9% reduction in compliance; P=0.016).

There were no significant differences in any of the other four quality of care indicators among the hospitals.

In 1991 Lomas and colleagues published the findings from a study in which they sought to compare the effects of local opinion leaders vs. standard audit and feedback on compliance with a clinical practice guideline for the management of women who have had a previous caesarean section.[81] They also found an improvement in compliance attributable to the use of local opinion leaders.

The study was conducted over a 24 month period from 1988 to 1989 in Ontario, Canada and followed up on the dissemination of a national clinical practice guideline. The clinical practice guideline was produced and disseminated in 1986 in collaboration with the Society of Obstetricians and Gynaecologists of Canada. The guideline contained clear statements addressing the high rates of repeat caesarean section for women who had a previous caesarean section. Recommendations for *trial of labour* with the intention of vaginal delivery for women with no absolute indication for repeat caesarean section (e.g. placenta previa) were made in the guideline.[82]

Hospitals recruited for potential participation in the study were community hospitals of at least 100 beds that did not have status as a teaching hospital, with a total of 51 hospitals in 24 counties being eligible. A random process was used to select 16 different counties and then one hospital was randomly selected from each of these 16 counties, all of whom agreed to participate. The 16 hospitals were randomly allocated to one of three study groups with; 1) eight hospitals in the guideline-only control group; 2) four hospitals in the guideline plus *audit and feedback* group and; 3) four hospitals in the guideline plus educationally influential *opinion leader* group.

All physicians practising in obstetrical care at the hospitals in the control group received only a mailed copy of the practice guideline in January 1988. Following the mail out, no further intervention was made.

All physicians practising in obstetrical care at the hospitals in the audit and feedback group received a mailed copy of the practice guideline *plus audit and feedback*. This involved conducting medical audits of the charts of all women with a previous caesarean section to determine actual practice and holding quarterly departmental meetings to conduct feedback and discussion of the audit results.

The opinion leader education group received a mailed copy of the practice guideline plus the opinion leader education intervention. A previously validated questionnaire[83] was utilised to identify one potential opinion leader in each participating hospital. Identified opinion leaders were provided with training in a one and a half day workshop on the evidence supporting the clinical practice guideline *and* principles of practice change. A package was then sent out to all physicians practising in obstetrical care at the hospitals in the opinion leader education group, mailed under the opinion leaders name, with a cover letter, information binder with a visually appealing shortened version of the guideline, a full copy of the guideline, bibliography of relevant studies and letters of support for the practice guideline and the study.

The primary outcome studied was the physicians' rates for *trial of labour* and vaginal birth over the 24 month study period. A total of 3,552 women were identified as having had a previous caesarean section in the study hospitals: 1,781 in control hospitals; 781 in audit and feedback hospitals and; 1,053 in opinion leader hospitals.

There were significantly higher rates of all outcomes in the opinion leader education group when compared to the control and audit and feedback groups. The rate of *trial of labour* was significantly higher (P=0.002) in the opinion leader education group at 38.2% (282/739)

compared to 28.3% (349/1,233) in the audit and feedback group and 21.4% (112/524) in the control group. The rate of vaginal birth after caesarean section was also significantly higher (P=0.003) in the opinion leader education group at 25.3% (187/739) compared to 14.5% (179/1,233) in the audit and feedback group and 11.8% (62/524) in the control group.

In 1998 Soumerai and colleagues reported the results of a study demonstrating that an *opinion leader* education and feedback intervention could significantly improve adherence to recommendations from the national American College of Cardiology/American Heart Association guidelines for the management of patients with acute myocardial infarction.[84]

The study was conducted in the state of Minnesota. From 45 eligible hospitals approached, 37 community hospitals agreed to participate. The study was a cluster RCT with randomisation occurring at the hospital level. There were 20 hospitals randomised to the intervention group and 17 hospitals randomised to the control group.

Baseline data on the use of study drugs was collected in all 37 hospitals from October 1st 1992 to July 31st 1993 with randomisation occurring on August 1st 1994. Potential study participants were identified from those patients with suspected acute myocardial infarction on hospital presentation. Patients were excluded if they died before admission, were transferred from a non-study hospital or had suffered an acute myocardial infarction in the two weeks prior to the study. Eligibility for study drugs was assessed in all included patients according to pre-specified criteria developed based upon the guidelines.

Two years prior to the commencement of the study, the guidelines that were utilised in the study were disseminated through a mail out to hospital administration, medical directors, and directors of quality management and nursing at all Minnesota hospitals, as well as to cardiologists and general physicians' offices.

In the control hospitals, in addition to the previous mail out of the guideline, the 17 hospitals were sent an audit report that summarised rates of study drug use in eligible patients

for each hospital involved in the study to allow them to compare their own rates of guideline adherence to other hospitals. No other intervention was provided.

In the opinion leader experimental hospitals, the first phase of the intervention was the identification of opinion leaders. A previously validated opinion leader identification instrument was mailed out to 772 physicians identified as being responsible for prescribing cardiac medications in study patients at baseline, with a 35.8% (294/772) response rate. In 17 out of the 20 hospitals, the first ranked opinion leaders received over 70% of votes at their hospital. The opinion leaders were invited to attend a one day meeting that promoted consensus and commitment to practice change according to the guideline recommendations. At these meetings, common barriers to change were identified and education on interventions to overcome these barriers was discussed. Feedback on current rates of adherence to the guidelines was provided in a report and opinion leaders also received educational tools for use in the participating hospitals.

Within their participating hospital, opinion leaders implemented educational interventions, including formal lectures and informal educational sessions, with colleagues. Opinion leaders were also encouraged to revise protocols, clinical pathways and standing orders in their participating hospitals.

There were no significant differences in the baseline characteristics of study groups, including no significant differences between the baseline rates of use of study drugs. The *opinion leader* intervention significantly increased the rate of *aspirin use* in elderly patients compared to the control intervention, where there was a reduction in the rate of aspirin use (17% vs. -4%, P=0.04). The opinion leader experimental intervention also significantly increased the rate of beta-blocker use in all acute myocardial infarction patients compared to the control intervention (63% vs. 30%, P=0.02). There was no impact on the rates of use for thrombolytics or lignocaine.

Majumdar and colleagues reported a small 171 patient study where the use of local opinion leaders was not found to have a significant effect on the translation of evidence from a clinical practice guideline to outpatient patient care.[85]

The study was conducted in patients with known cardiovascular disease residing in Alberta and evaluated whether a *local opinion leader endorsed one page evidence summary* mailed to general physicians could improve prescribing practices of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers for patients with heart failure, and 3-hydorxy-3-methylglutaryl coenzyme-A-reductase inhibitors (statins) for patients with ischaemic heart disease.

The study was a cluster RCT, with randomisation completed at the general physician (not individual patient) level using a computer generated randomisation sequence. All patients enrolled in the trial were then evaluated as intervention or control according to the group that their treating physician was randomised to.

Opinion leaders were identified through the use of a previously validated instrument that was mailed to all 788 regional general physicians in the Alberta region.[83] There was a 30% (236/788) response rate to this mail-out, with five physicians 'consistently nominated' as opinion leaders by the respondents.

The intervention provided by the opinion leaders was a condition specific one page evidence summary generated in the form of a letter addressed to the general physician which identified the patient, their diagnosis (heart failure or ischaemic heart disease), briefly described the key evidence supporting the study medications and was signed by all five opinion leaders. This was faxed to the physician with the patients' most recent medication profile. The control intervention group received a faxed copy only of the patients' most recent medication profile.

Pharmacies in the Alberta region (n=244) were contacted and asked to participate in the study, with recruitment stopped once the sample size target of 40 pharmacies was reached. Patients were identified through the dispensing records of participating pharmacies, with patients with a prescription for specific medications used to treat cardiovascular disease (loop diuretics for heart disease and short acting nitrates for ischaemic heart disease) approached for consent to use their medical records.

During the study period from January 2002 to June 2005, a total of 2,897 patients were screened for eligibility, with 171 patients identified with heart failure or ischaemic heart disease who were not currently receiving the study medications prior to study start selected for inclusion. There was no loss to follow-up and all analyses were conducted on an intention to treat basis. Despite small improvements in the rates of prescribing cardiovascular medications within six months of study period, the results were not statistically significant in this small sample of 171 patients.

Targeted educational interventions

The authors of a small 88 patient study published in 2002 demonstrated that a *case based learning programme* for general practitioners resulted in improved adherence to clinical practice guideline recommendations for treatment recommendations with lipid lowering therapy.[86]

The study was a cluster RCT involving 14 primary health care centres in Södertälje, Sweden. Each health care centre was matched with a second health care centre, taking into account patient and physician location, numbers, relationships, and the socioeconomic status of the patient populations. Within each matched pair, one centre was randomised to intervention or control groups. The resulting two groups contained 26 and 28 general practitioners, with an equal sex and age distribution.

Patients with a diagnosis of coronary artery disease who had visited the department of medicine at Södertälje Hospital in the year preceding the study were identified from the patient registry of Stockholm City Council and invited to participate. Patients were analysed in the control or intervention group according to which group their primary general practitioners health care centre was already randomised to.

The *case based learning programme* intervention involved the presentation of three to four seminars during the study year, conducted as an educational session with the presentation of a case scenario followed by an interactive discussion to problem solve. The session was only delivered to general practitioners in the intervention group and was facilitated by a local cardiologist.

The control group received no further intervention other than the initial distribution and presentation of the practice guideline.

A total of 88 patients were enrolled into the study, 43 in the control group and 45 in the study intervention group.

The main study outcome was the measurement of low density lipoprotein cholesterol levels in study patients. In the intervention group, low density lipoprotein cholesterol levels were significantly lower ($P<0.05$) after two year follow up than in the control group (3.7 mmol/L vs. 4.1 mmol/L).

Succinct and concise evidence summary documents

Clinicians consistently report underuse of detailed systematic reviews to support clinical practice decisions.[34-36, 44] A *succinct and concise evidence summary* attempts to overcome time pressure related barriers to the use of systematic reviews by presenting key aspects of a systematic review in a much briefer format.[58, 87-89]

In 2013 Perrier *et al.*[58] published a paper outlining the structured process undertaken by their group to develop a shortened systematic review format that resulted in a *succinct and*

concise evidence summary tool. They describe a development process that included four phases: 1) selection of a systematic review and creation of initial prototypes; 2) a formal mapping exercise to identify barriers to practice change and formally link each barrier with a unique characteristic of the evidence summary tool; 3) an expert evaluation of usability of the tool and 4) a clinical content review.

In the first phase of the development of their *evidence summary tool*, the investigators selected a published systematic review relevant to primary care that would serve as a useful template example to condense. The chosen publication was a systematic review of *rosacea* (adult acne) treatments published in 2007 by van Zuuen *et al.*[90] The *evidence summary tool* was limited to a double-sided page in length with a focus on usability, usefulness and accessibility.

During the mapping exercise conducted in phase two of the development process, barriers faced by clinicians when seeking research evidence to answer clinical questions were identified. Explicit design features were incorporated into the summary tool in an attempt to address each barrier. A total of 59 barriers were identified and grouped into five main domains; 1) obstacles related to recognising an information need; 2) obstacles related to formulating the question; 3) obstacles related to seeking information; 4) obstacles related to formulating the answer; and 5) obstacles related to using the answer to direct patient care.[91] These 59 barriers were reviewed and reduced to 23 obstacles the researchers believed an evidence summary tool could overcome (See **Table 3**)

Table 3 Intrinsic obstacles to be overcome by an evidence summary tool.

Obstacles reported by clinicians when using evidence summary resources
Key aspect of topic not included in a resource that should logically include it (Ex. Drug dosing not reported).
Resource poorly organized.
Resource not clinically oriented.
Resource not authoritative or not trusted.
Resource not current.
Information incorrect.
Information not current.
Failure to define important terms.
Vague or tangential information included.
Unnecessarily cautious writing style.
Tertiary care approach to primary care problem.
Biased information due to conflicts of interest.
Failure to address the actual clinical question.
Failure to report the comparison of interest.
Failure to report the outcome of interest.
Failure to report the population of interest.
Evidence based on flawed methods.
Failure to cite or include key relevant evidence.
Failure to directly or completely answer the question.
Answer directed at the wrong audience.
Difficulty addressing unrecognised information needs apparent in the question.
Answer not trusted.
Answer inadequate.

An inspection of the shortened systematic review format was conducted with mapping of specific strategies used in the tool to address each of the 23 intrinsic obstacles. For example the item *resource poorly organised* was addressed by using a table format to present information, with headings used within the table to organise and emphasise key information. The item *resource not current* was addressed through reporting of the date that the tool was created and the dates of any literature searches conducted. The item *answer not trusted* was addressed through the inclusion of the full citation of the original systematic review in the masthead of the document so that the user could make a judgement as to their belief in the trustworthiness of the source. The mapping exercise highlighted five items that were not addressed in the shortened review format which prompted the inclusion of additional

strategies to address each. For example the item *failure to define important terms* was not addressed, so the Authors included appropriate definitions of key terms (e.g. odds ratio etc).

In stage three of the development process the authors engaged an external expert, with experience in research and human factors technology, to conduct a usability inspection of the tool. The evaluation identified no *major* usability issues, however *moderate* usability issues identified included wording that was potentially confusing to readers, placement of information that was inconsistent, or omissions that were potentially confusing. *Minor* issues including small font size and layout were also identified.

The final stage of the development process was a clinical content review. The clinical content review was conducted by a family physician that identified small errors in the presentation of the case-based tool. Each phase of the development process stimulated alterations to the two evidence summary tool formats, with modifications made accordingly to result in the final prototypes.

Following on from their publication in 2013 that outlined the development of their two evidence summary tool formats, in 2014 Perrier *et al.* conducted two rounds of focus groups with physicians to gain feedback on the presentation, layout, design and content of the two tools in order to determine the optimal format of the final design.[87]

The study involved family physicians recruited through attendance at formally planned educational events conducted by the Office of Continuing Education and Professional Development at the University of Toronto, or by referral from participants already enrolled. Participants were sent a recruitment e-mail prior to attendance at events, or recruited directly during attendance at events. Written informed consent was obtained from participants, and confidentiality was maintained during reporting of focus group feedback. Participants were incited to participate with the offer of lunch and an honorarium fee.

Three major themes were identified from the first round of focus groups; ease of use, clarity and implementation. Issues raised by participants that related to ease of use included: wanting to see information presented in a more intuitive manner, flagging important information for the reader through use of highlighting or bold text, and clearly identifying when no information was available. Participants identified that clarity could be improved by modifying the layout and content of the documents, for example by presenting information in tables. Despite not traditionally being available in a systematic review, participants identified wanting information included to direct them how to implement the summarised intervention in clinical practice.

After modification in response to the first round, the second round of focus groups resulted in the emergence of four major themes: ease of use, clarity, brevity and implementation. The feedback and issues raised surrounding ease of use; clarity and implementation were similar to what was provided from participants in the first round of focus groups. However, in the second round, participants also highlighted that the prototypes included repetitive information and suggestions were made to shorten the document and focus on brevity to aid in understanding and rapid use.

After refining their instrument in response to focus group feedback, Perrier *et al.* conducted a *usability study*.[88] This study involved iterative cycles of testing with family physicians in order to identify any remaining areas requiring modification in the prototypes of their two evidence summary tools.

Primary care physicians were recruited to participate in the usability study from the list of registered physicians with the College of Physicians and Surgeons of Ontario, Canada. From the 13,298 active family physicians and 3,520 general internists on the list, 152 were e-mailed and informed about the study. It is unclear how the investigators selected which physicians were e-mailed. The physicians were asked to reply indicating a time and date that

they were available to participate. An honorarium fee was offered to encourage participation.

Six physicians responded to the recruitment e-mail, with an additional four physicians

recruited through referral by those six participants. The participants included five men and

five women, with ages ranging from 30 to 65 years of age.

The usability testing was conducted in three iterative cycles, with two participants

involved in the first cycle, three participants involved in the second cycle and five participants

involved in the third cycle. In each cycle participants were presented with the evidence

summary tools in random order. They were given case scenarios and asked to complete a task

relevant to the case scenario. Investigators observed and recorded participants as they

interacted with the reviews and case scenarios, and conducted semi-structured interviews to

learn about user satisfaction and to obtain feedback on improving the evidence summary tool.

Between each cycle of testing, modifications were made to the evidence summary tool

based on feedback from participants, with the next cycle using the updated documents. After

the first cycle, the investigators made key information more *prominent* so that it could be

found more readily. Following the feedback from the second cycle, the investigators made

explanations more distinct. After feedback from the third cycle, no additional modifications

were required and a decision was made to stop recruitment of participants and end the

usability testing.

In 2015 Perrier *et al.* reported the results of a pilot RCT evaluating the ability of their

evidence summary tools to *inform clinicians* and to *guide clinical decision making*.[89]

A list of potentially eligible participants was obtained from *Scott's Canadian Medical*

Directory. An honorarium payment was offered as an incentive for participation. Physicians

involved in any of the three previous studies[58, 87, 88] during which the evidence summary tools

were developed and tested were excluded from recruitment.

One thousand seven hundred and fifty recruitment e-mails were sent to potential participants, with 67 physicians responding and volunteering to participate.

When participants visited the study website, they completed a screening questionnaire to determine eligibility. If eligible, they were directed to complete a consent form. Following consent they were randomly allocated to receive one of three different information sources: 1) a full length systematic review; 2) an evidence summary tool, and; 3) a case-based evidence summary tool. Both versions of the evidence summary tools focused on presenting the evidence reported in the systematic review provided to the first group.

Eleven of the physicians who were consented and randomised failed to complete the pilot study, it is unclear which groups they were allocated to. From the 56 physicians who completed the pilot study, 22 were females and 34 were males. Eighty seven percent (49/56) had over 10 years experience practicing medicine. Half of the participants (28/56) indicated they had not participated in critical appraisal training and 96.43% (54/56) stated they had not conducted or published a systematic review.

After reading their allocated information source (systematic review, evidence summary tool or case-based evidence summary tool), participants were presented with three questions: 1) Based on the information source you just read, please summarise the *clinical bottom line;* 2) After presentation of an appropriate clinical scenario, participants were asked *would you apply the evidence* you just read to this scenario and; 3) If they answered yes to question 2, the third question asked them to outline *how they would apply the evidence* to the case scenario. Agreement between groups was measured using a kappa statistic.

For the first question, providing the *clinical bottom line* the kappa statistic was 1.00, indicating excellent agreement between groups. The kappa statistic of 1.00 for questions regarding *applying the evidence* from the systematic review or evidence summary to the case scenario provided also indicated excellent agreement. These high levels of agreement

demonstrate that clinicians from each of the groups took away the *same clinical bottom line* and *applied the evidence* to the clinical scenario in the same way. Because there was *no information lost* as a result of the summary process required to shorten the content of the systematic review to fit the design constraints of the summary tool, this pilot project provided important safety information to inform the conduct of a larger evaluation of the effectiveness of the evidence summary tools.

METHODS

Purpose

The purpose of this study was to explore attitudes towards the use of published research evidence in intensive care medicine and, based on an understanding of factors that inhibit and/or facilitate the appropriate use of published research evidence, to develop and evaluate an intervention to improve the use of research evidence by intensive care clinicians.

To this end, we undertook a series of studies. We conducted a mail survey of intensive care specialists in Australia and New Zealand to understand attitudes, knowledge and current patterns of use of published research evidence in intensive care medicine. In response to insights gained from this initial survey, we developed two evidence summary tools to facilitate the appropriate use of published research evidence and, finally, we conducted an international on-line interventional study to evaluate the effectiveness of the summary tool.

Study Aims

Aim 1: To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst intensive care specialists in Australia and New Zealand.

Aim 2: To assess the level, patterns and characteristics of *appropriate use* of research evidence in intensive care medicine in Australia and New Zealand using a metric proposed and evaluated by De Vito *et al.*[45]

Aim 3: To investigate whether identifiable clinician-level factors, characteristics of research studies, and factors that may inhibit research use are associated with the *appropriate use* of published research evidence in intensive care medicine.

Aim 4: To design an intervention or tool to improve the use of published research evidence in clinical decision making.

Aim 5: To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst a *multinational* mixed group of intensive care clinicians.

Aim 6: To conduct an intervention to determine whether an *evidence summary tool* can improve the use of published research evidence to support clinical decision making.

Aim 7: To evaluate competing versions of the evidence summary tool to determine whether specific elements of presentation of the tool can enhance the use of published research evidence to support clinical decision making.

Aim 8: To investigate whether clinician-level factors, research experience, characteristics of research use and research attitudes predict the likelihood of practice change in response to using an evidence summary tool.

Ethics and consent

This study was designed in compliance with the National Statement on Ethical Conduct in Research Involving Humans.[92] Ethics approval was gained from the University of Sydney Human Research Ethics Committee (protocol number 13029; September 2010) (protocol number 2015/634; August 2015). Appendix A contains the letters of approval from the University of Sydney Human Research Ethics Committee for protocol 13029 and protocol 2015/634. The study documents approved by the University of Sydney Human Research Ethics Committee for use in this project can be found in Appendix B, Appendix C, Appendix D and Appendix E.

Data collection in this study involved the use of two separate self-administered questionnaire instruments, with submission of a completed questionnaire by a participant taken as an indication of voluntary consent to participate in the study. Recruitment correspondence with potential participants outlined that participation was voluntary, that there

would be no repercussion for non-participation, that they could withdraw from the study at any time, and that survey completion and submission was considered consent to participate.

Summary of methods used to achieve each Aim

Aim 1

To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst intensive care specialists in Australia and New Zealand, a methodologically rigorous mail survey of a representative random sample of intensive care specialists was conducted.

A complete list of all practicing intensive care specialists in Australia and New Zealand was obtained from the College of Intensive Care Medicine. A random sample was identified by use of a random number list and blinded numbered postal surveys were sent by a nominated officer of the college. Responses were tracked by recording the identifying number of surveys as they were returned. Up to three repeat mail outs were completed according to the *Dillman total design method* in order to maximise response rates.[93]

Aim 2

The metric proposed by De Vito *et al.* was utilised to calculate rates of *appropriate use* of research evidence.[45] *Appropriate use* was defined as a participant who reported that they *sometimes, often or always read* RCT's and meta-analyses and they *sometimes, often or always used* RCT's and meta-analyses to support clinical decisions. Under this definition of *appropriate use*, when someone reported they *rarely or never read* RCT's and meta-analyses and they *rarely or never used* RCT's and meta-analyses to support clinical decisions they would not be classified as an appropriate user.

Clinician-level characteristics, behaviours and beliefs were compared and contrasted between *appropriate* users and *non-users*.

Aim 3

To identify clinician-level factors, characteristics of research studies, and factors that may inhibit research use that were associated with the *appropriate use* of published research evidence in intensive care medicine, multivariable logistic regression analysis was conducted.

Factors under study were identified for evaluation in multivariable regression if the univariable P-value was less than 0.10. Backwards stepwise elimination was used to develop a final model to identify all statistically significant independent predictors of appropriate use.

Aim 4

To design an intervention or tool to improve the use of published research evidence in clinical decision making, an extensive review of published literature regarding interventions for addressing evidence-practice gaps was undertaken. Combined with an understanding of the factors that may inhibit appropriate evidence use by intensive care clinicians, an *evidence summary tool* was identified as the most appropriate tool.

A mapping exercise was conducted to explicitly identify factors that inhibit the use of research evidence and guide the selection of design features for inclusion in the evidence summary tool. Two versions of the *evidence summary tool* were designed to overcome competing factors identified in Aim 3.

Aim 5

To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst a *multinational* mixed group of intensive care clinicians, a methodologically rigorous online survey was conducted. The sampling frame included all subscribing members of the online critical care special interest discussion forum *CCM-L,* which is run out of the University of Pittsburgh. An e-mail invitation to participate was sent to all registered members of the list. Members who volunteered to participate in the

study were e-mailed the study questionnaire for completion and return via an anonymous and secure web-based drop box.

Aim 6

To determine whether an *evidence summary tool* can improve the use of published research evidence to support clinical decision making, a case-based scenario evaluation was designed. The international cohort of intensive care clinicians who volunteered to participate in the online questionnaire survey on attitudes towards research evidence were also presented with the case-based scenario evaluation of the evidence summary tool. Using a before-and-after design, *a change in belief in the benefit* of the clinical intervention summarised in the evidence summary tool for the patient described in the case-based scenario was assessed.

Aim 7

To evaluate *competing versions* of the evidence summary tool, participants in the international online questionnaire survey on attitudes towards research evidence were *randomly assigned* to receive one of two alternate versions of the evidence summary tool. Participants were randomised on enrolment into one of two groups, with each group allocated a different version of the evidence summary tool.

Using this randomised design, *a difference between groups* with regards to *belief in the benefit* of the clinical intervention summarised in the evidence summary tool for the patient described in the case-based scenario was assessed.

Aim 8

To investigate whether clinician-level factors, research experience, characteristics of research use and research attitudes predict the likelihood of practice change in response to using an evidence summary tool, multivariable least-squares regression analysis was conducted.

Factors under study were identified for evaluation in multivariable regression if the univariable P-value was less than 0.10. Backwards stepwise elimination was used to develop a final model to identify all statistically significant independent predictors of the likelihood of change.

Detailed methods

Aim 1: To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst intensive care specialists in Australia and New Zealand.

Survey instrument development and design

The study involved a self-administered quantitative mail-out questionnaire survey of volunteer participants recruited from amongst all intensive care clinicians registered for practice in Australia and New Zealand.

To inform the design of the survey instrument a literature search was conducted. Published studies evaluating physicians' attitudes towards research evidence, the use of research evidence by physicians in clinical practice, or barriers towards the use of research evidence in clinical practice were obtained.[34-36, 39-45, 51, 68, 94] In addition to the primary literature search, references from identified questionnaires were reviewed and obtained.

A structured, self-administered mail out quantitative questionnaire was developed with a major focus on questions and elements taken from two key studies identified in the literature search.[34, 45] The questionnaire was designed using Microsoft Office Word[a] and then following completion, a PDF printable version of the questionnaire was created using Adobe Acrobat Pro 9[b].

---

[a] Microsoft Corporation, Redmond, WA, USA.
[b] Adobe Systems, San Jose, CA, USA.

Key elements of good survey design included the use of single-sided pages with a minimum font size of 12 points and limited use of bulk capital letters. Sections were separated with a single black line within the document and new questions were highlighted in bold. Careful consideration was given to limiting the amount of information collected in demographics in order to minimise reduced response rates from perceived threats to maintenance of anonymity.[95]

Although a formal cover page was not to be included, the first page of the questionnaire highlighted the short title, with the primary investigator's name (PTH) and contact details, along with brief instructions on how to complete the survey question. As each question was presented, if the format of the question or the response options were changed from the previous question, clear instructions were provided to enable the respondent to complete the questionnaire without having to turn back pages and review prior instructions for clarification.[96] The final format of the questionnaire along with the complete wording of all questions in each section can be seen in Appendix C.

Pilot Testing

The questionnaire instrument was pilot tested for face validity and content validity by three intensive care clinicians. Pilot testers were selected by the primary investigator (PTH) based upon their similarity to the intended study population. The pilot testers were provided with specific instructions by the primary investigator (PTH) for completion of the pilot testing activity.

Pilot testers were instructed to complete the questionnaire in full and take note of the time it took to complete the questionnaire. They were then asked to go back to consider and comment specifically on what they thought each question was asking, and provide feedback on clarity and overall readability, noting any difficulties in completing or understanding the questionnaire. Feedback was sought specifically on grammar, the flow and order of the

survey, any technical difficulties encountered during completion and general appearance of the survey.

The responses and feedback from all three pilot testers were reviewed by the primary investigator, with questions and formatting modified according to the feedback received to improve clarity, readability and usability. One iteration of pilot testing was conducted.

Sampling frame and randomly selected survey population

The intended target population for this study was intensive care specialists currently practicing in the field of intensive care medicine in Australia or New Zealand. The registration list of the College of Intensive Care Medicine (CICM), a medical specialty college statutorily responsible for specialist training and education in the specialised area of intensive care medicine in Australia and New Zealand was used as the sampling frame for obtaining the study population.

At the time of submission of the ethics application for approval to conduct the study in May 2010, the CICM reported 685 registered members. Each of these registered members were assigned a membership number by the CICM at the time of their registration. These membership numbers ranged from number one (1) for the first member registered by the CICM to number 685, for the most recently registered member. To select a random subset of all members to be invited to participate in the study, SAS Version 6.2[c] was used to generate a list of random numbers between 0 and 685.

Sample size

Standard formulae for a simple random sample were used to calculate the sample size for this study:[97]

$$n = 4P(1-P)/L^2$$

$$1/n* = 1/n + 1/N : \text{sampling fraction adjustment}$$

---

[c] SAS Institute, Cary, NC, USA.

Given a 32.1% (P) rate of expected appropriate use of evidence as per the results of De Vito *et al.*,[45] and a total population (N) of 685 physicians, a sample of **238** (n*) physicians would provide a precision (L) of five percent on the estimate of appropriate use, adjusted for the sampling fraction (n/N) being greater than ten percent of the total population.

With this sample size, if a minimum 70% response rate was obtained, 6.3% precision would be achieved, which was deemed acceptable to allow the aims of the study to be attained. In the formula used, the term precision relates to the 95% confidence interval around the observed result. A range of plus or minus 6.3% in the 95% confidence interval represents very precise results. Optimal survey methods were employed to maximise the chance of a 70% response rate.[93, 98]

Survey packages

Survey packages contained the survey instrument questionnaire, instructions for completing the questionnaire, a reply-paid stamped A4 response envelope, and a cover letter. Each survey package was marked with *a survey identification number* from 1 to 238.

The cover letter outlined the purpose of the project and requested participation through completion and return of the questionnaire, along with assurances of the maintenance of confidentiality and anonymity.

The reply-paid envelopes were addressed to the investigators and were also marked with the survey identification number enclosed in the package to enable tracking of responses. The cover letter and participant information statement were provided as approved by the University of Sydney Human Research Ethics Committee (see Appendix B).

Survey packages were prepared by the study investigators (PTH and GSD) and delivered to the CICM for distribution to the randomly selected potential participants.

Maintenance of anonymity and mail out procedure

Along with the 238 survey packages, a master list linking *the survey identification number* on a specific package to the intended recipient was provided to the CICM. The intended recipient was identified on this master list using their assigned CICM membership number. The investigators did not have access to member's names, only membership numbers. In order to ensure the confidentiality and anonymity of their members, the CICM designated one officer from the CICM to handle the generation of mailing address labels based on membership numbers supplied by the investigators. These mailing address labels were then applied to the survey package with the survey identification number assigned to that specific member, thus preventing the investigators from access to any identifying details of the CICM members.

At no time prior to, during, or after the conduct of the study were the investigators given access to the identifying details of the CICM members.

The first mail out of survey packages was conducted in January 2011, with two follow up mail outs conducted at four week intervals.

Follow up mail outs

A copy of the master mail out list was kept by the primary investigator. When a numbered reply paid envelope containing a survey was returned to the investigators, the corresponding survey identification number was removed from the master mail out list, thus creating a list that contained only non-responders.

Following an interval of four weeks, the list of non-responders was sent to the CICM officer, along with new complete survey packages that contained the survey instrument questionnaire, instructions for completing the questionnaire, a numbered reply-paid stamped A4 response envelope, and an updated cover letter highlighting that this was a follow up mail out.

As per the first mail out, responders to the second mail out were marked off the list as surveys were returned to the investigators.

Following an interval of four weeks after this second mail out, the list of non-responders was again sent to the CICM officer, along with new complete survey packages that contained the survey instrument questionnaire, instructions for completing the questionnaire, a numbered reply-paid stamped A4 response envelope, and an updated cover letter highlighting that this was a follow up mail out.

Following the third mail out, the study was promoted at the annual CICM conference, by the CICM meeting convenor. The meeting convenor encouraged members who had received a survey to complete and return the survey to the study investigators.

Data Management

All aspects of data management including data entry, data analysis, verification of data and storage of data, were conducted by the primary investigator at the Northern Clinical School Intensive Care Research Unit, located on campus at the Royal North Shore Hospital, Sydney. A custom Excel spreadsheet was developed using Microsoft Office[d] for input of data.

Following initial entry of the data, accuracy checks were conducted by the primary investigator on database entry, with clear errors and out of range mistakes corrected to the paper source record. On completion of database cleaning by the primary investigator, a colleague from the Northern Clinical School Intensive Care Research Unit who was not involved in the conduct of the project conducted an audit of the accuracy of data transcription by comparing fifty percent of all database entries directly to the paper source documents.

Statistical analysis

Quantitative data was presented using descriptive statistics. Because most responses to balanced Likert scales demonstrate Normal distributions, results are reported as mean and

[d] Microsoft Corporation, Redmond, WA, USA.

standard deviation (SD),[99] or rates with numerator and denominator when appropriate. Ninety-five percent confidence intervals were reported where appropriate. All calculations were conducted using SAS Version 6.2[e].

Aim 2: To assess the level, patterns and characteristics of appropriate use of research evidence in intensive care medicine in Australia and New Zealand using a metric proposed and evaluated by De Vito et al.[45]

Appropriate use was defined according to the metric established by De Vito *et al.*[45] as *to sometimes, often or very often* **read** *RCT's and meta-analyses AND to sometimes, often or very often* **use** *RCT's and meta-analyses*.

To identify appropriate use, the following key questions and response items from De Vito *et al.*'s study were included in the current questionnaire:

Question 27) - How often do you read the following?

 (a) published RCTs;

 (e) published meta-analyses.

Question 28) - How often do you use the following information sources to guide decisions in your clinical practice?

 (e) the results of an RCT;

 (i) the results of a meta-analysis.

Response options for these questions were presented on a balanced five-point Likert scale. Respondents were able to select from the options *never, rarely* (defined as once or twice a year), *sometimes* (defined as every month or so), *often* (defined as every week or so) or *very often* (defined as every day or so). The complete wording of the questions and all response items can be viewed in the questionnaire in Appendix C.

---

[e] SAS Institute, Cary, NC, USA.

A response of *sometimes*, *often* or *very often* for questions 27(a), 27(e); 28(e) and 28(i) was classified as a positive response in the *appropriate use* metric. A response of *never* or *rarely* for questions 27(a), 27(e); 28(e) and 28(i) was considered a negative response and was not scored in the *appropriate use* metric.

To assess the *level* of appropriate use of research evidence amongst Australian and New Zealand intensive care specialists, a simple rate was calculated according to the following formulae:

$$(n/N) \times 100$$

where (n) is the number of appropriate users and (N) is the total number of respondents evaluated in the appropriate use metric.

Statistical analysis

To assess the patterns and characteristics of appropriate use, characteristics, behaviours and beliefs were compared and contrasted between appropriate users and non-users. Comparisons were conducted using t-tests or chi-square tests where appropriate. If group size for any cell for a chi-square test was less than five, Fisher's Exact Test was calculated.

A P-value less than 0.05 from an appropriate statistical test was accepted to identify *statistical significance.* A P-value less than 0.10, but greater than or equal to 0.05, from an appropriate statistical test was accepted to identify a *trend* towards statistical significance. All analysis was conducted using SAS Version 6.2[f].

---

[f] SAS Institute, Cary, NC, USA.

Aim 3: To investigate whether identifiable clinician-level factors, characteristics of research studies, and factors that may inhibit research use are associated with the appropriate use of published research evidence in intensive care medicine.

Logistic regression model development

The primary outcome for this analysis was the binary variable *appropriate use yes/no*. The purpose of this undertaking was to identify clinician-level factors and characteristics of research evidence that are *independently associated* with appropriate use. To this end, a multivariable logistic regression model was developed.

Univariable logistic regression was undertaken to identify clinician-level factors and characteristics of research papers that would qualify for inclusion in the *maximum model*.

Clinician-level factors or characteristics of research papers with a univariable P-value less than 0.10 were included in the *maximum model*.[100] Backwards stepwise elimination was used to identify variables for removal from the maximum model. At each step, a P-value was calculated for each variable in the model, and the variable with the highest P-value was eliminated from the model. All P-values were then re-calculated for all variables remaining in the model. This process was continued until all remaining P-values were less than 0.05.[101]

A clinician-level factor or characteristic of a research paper was declared to be significantly and independently associated with appropriate use if it remained in the final multivariable model and had a P-value of <0.05.[102]

Aim 4: To design an intervention or tool to improve the use of published research evidence in clinical decision making.

An extensive review of published literature regarding interventions for addressing evidence-practice gaps was undertaken. This review identified a number of interventions or tools that qualified for consideration. These included: clinical practice guidelines;[69, 70] simple

reminders;[78] printed guideline summaries;[60] academic detailing;[79] opinion leaders;[80, 81, 84] targeted educational interventions;[86] and evidence summary tools.[58]

After careful consideration of the theoretical framework proposed by Haynes *et al.* that consistently placed evidence summary resources at the top of the hierarchy of research evidence,[54-57] and the promising work by Perrier *et al.*[58, 87-89] an *evidence summary tool* was identified as a viable approach in need of more extensive evaluation.

Evidence summary tool development and design

A four-stage process was utilised to guide the development and design of the evidence summary tool:

1. Updated focussed literature review on evidence summaries and barriers to evidence uptake.

2. Recognised common barriers encountered by clinicians and ensured key design elements of the summary tool addressed each identified barrier.

3. Selected a *clinical intervention* and identified all *research evidence* supporting that intervention for summarisation in the tool.

4. Pilot tested for usability and clinical content.

Stage one – Literature search

To inform the design of the evidence summary tool a focussed literature search was conducted to identify published studies evaluating the development or design of any type of evidence summary resource or tool.[103] A secondary focussed search identified publications that reported clinicians' attitudes towards research evidence, factors that influence or inhibit the use of research evidence by physicians, preferences for research evidence, or barriers to the use of research evidence in clinical practice.

Stage two - Mapping design elements to each barrier

Identification of barriers commonly encountered when answering clinical questions

Based upon the publications identified in the secondary literature search, barriers commonly encountered by physicians when answering clinical questions were identified and explicitly listed. Two study investigators (PTH and GSD) independently reviewed the list and assessed each barrier for relevance and the ability to be addressed within the evidence summary tool design. Each barrier was categorised as able to be addressed or unable to be addressed. The two study investigators reviewed the individual ratings of relevance, resolving any differences of opinion by discussion until consensus was achieved.

Identification of design elements to address identified barriers

The mapping exercise identified explicit design elements of the summary tool that were appropriate for addressing each of the identified barriers. The two study investigators met to review proposed design elements, resolving any differences in opinion by discussion to create, by consensus, a final list of design elements to address each barrier within our evidence summary tool.

Incorporation of design elements into template and first draft of evidence summary tool

A structured single-sided one page evidence summary tool template was designed. The single page was split into specific sections, with each section clearly separated by a brightly coloured banner. Each section was given a short heading, used to convey the key message or content contained within the section, with bold font utilised to enhance the section headings.

There was minimal use of font less than 12 points and limited use of bulk capital letters. Colour was incorporated into the design of the evidence summary tool to enhance the visual appeal of the document. A coloured text box that was placed at the top of the document was used to highlight a clear title conveying the primary message of the evidence summary tool, the name and contact details of the primary investigator responsible for the development of the tool, and the credible body responsible for oversight of the tool. In this case, the

University of Sydney Northern Clinical School Intensive Care Research Unit served as the credible body.

Stage three - Selection of a clinical intervention

A clinical intervention was sought that was supported by evidence that contained as many of the characteristics of research evidence that were found to be statistically significantly associated with *appropriate use* (see Aim 3). In addition, it was required that there was a documented evidence-practice gap for the candidate intervention. Once the intervention was identified, a literature search was conducted to identify all RCTs and systematic reviews published with a focus on the intervention.

After identification of the supporting evidence, the two study investigators independently abstracted key details from each study with regards to the target population and intervention. The methodological validity of the identified supporting evidence was also evaluated independently by the two investigators. Methodological validity focussed on the key criteria of allocation concealment, completeness of follow-up, blinding, intention to treat, post-hoc exclusions and early trial discontinuation.

Stage four - Pilot testing

Two practicing intensive care clinicians who were not involved in the development of the evidence summary tool were invited to undertake pilot testing. They were asked to act as expert reviewers to evaluate the usability and clinical content of the evidence summary tool.

All original source evidence supporting the chosen clinical intervention was provided to the pilot testers. They were not required to evaluate the validity of the original evidence but they were required to evaluate the accuracy of the clinical content of the summary tool. Feedback was sought specifically on wording or grammatical suggestions, the flow and order of the evidence summary tool, the general appearance and visual appeal of the tool and any other issues they thought relevant.

The feedback from the pilot testers was reviewed by the primary investigator (PTH) and was used to guide modifications to the layout and content of the evidence summary tool to improve clarity, readability and usability. One round of pilot testing was conducted with each pilot tester and the tool was finalised.

Aim 5: To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst a multinational mixed group of intensive care clinicians.

Survey instrument development and design

The study involved a self-administered quantitative online questionnaire survey of volunteer participants recruited from an international critical care special interest e-mail discussion group.

To inform the design of the questionnaire instrument, a literature search was conducted. Published studies evaluating intensive care clinicians' attitudes towards research evidence, the use of research evidence by intensive care clinicians in clinical practice, or barriers towards the use of research evidence in intensive care medicine were obtained.[104]

A structured self-administered questionnaire tool was prepared modelled largely on a published study investigating the use of research evidence amongst intensive care clinicians by Heighes and Doig.[104] The questionnaire was designed using Microsoft Office Word[g] and then following completion a live PDF form version of the questionnaire was created using Adobe Acrobat Pro 9[h]. All responses were captured electronically, directly in the PDF form.

Key elements of good survey design included the use of single-sided pages with a minimum font size of 12 points and limited use of bulk capital letters. Sections were separated with a single black line within the document and new questions were highlighted in bold.

---

[g] Microsoft Corporation, Redmond, WA, USA.
[h] Adobe Systems, San Jose, CA, USA.

Careful consideration was given to limiting the amount of information collected in demographics in order to minimise reduced response rates from perceived threats to maintenance of anonymity.[95]

Although a formal cover page was not to be included, the first page of the questionnaire highlighted the short title, with the primary investigator and contact details, along with brief instructions on how to complete the survey question. As each question was presented, if the format of the question or the response options were changed from the previous question, clear instructions were provided to enable the respondent to complete the questionnaire without having to turn back pages and review prior instructions for clarification.[96] The final format of the questionnaire along with the complete wording of all questions in each section can be seen in Appendix E.

Electronic data capture and on-line resources

Following completion of the initial questionnaire design in Word, the document was converted into an active PDF form using Acrobat Pro 9[i]. Using the Adobe *Form Wizard* function, editable form fields were created with basic range checking to allow electronic data capture. Respondents were also able to print the form and fill in by hand, if desired (See Figure 5 next page).

---

[i] Adobe Systems, San Jose, CA, USA.

Figure 5. Adobe Form Wizard: Radio button and text field insertion.
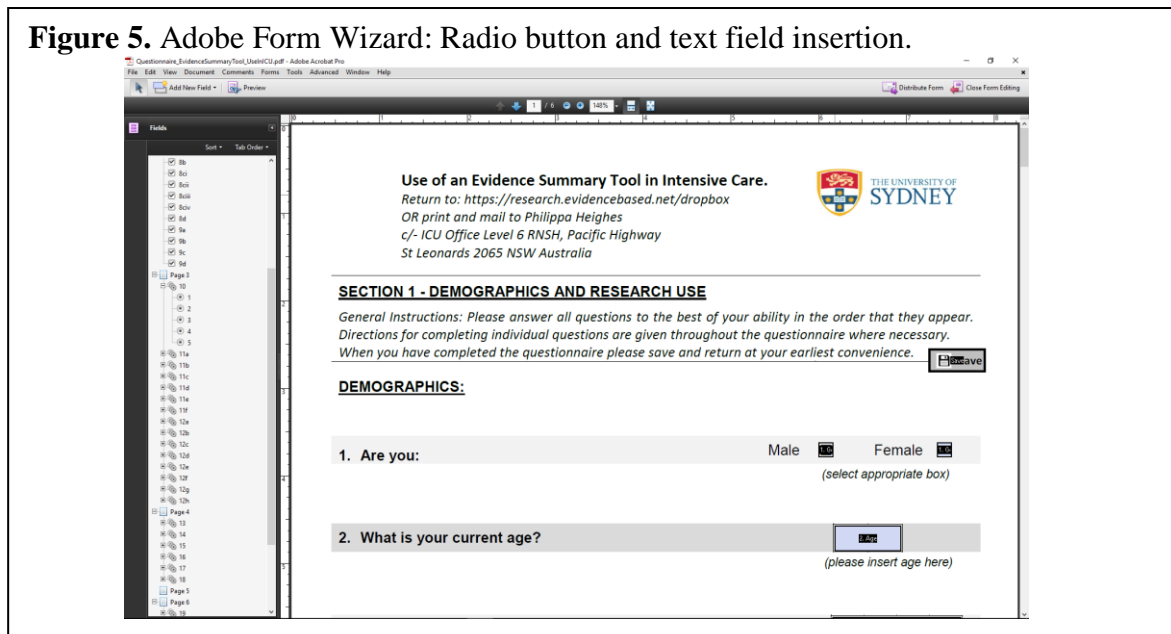
For response options that required respondents to only select one answer from any given options, the *radio button feature* was utilised. For example, question one asked respondents to indicate their gender from the allowable response options of male or female. Using the radio button feature, respondents could click on male or female but were unable to select both options. If they attempted to change their response, their initial selection would be removed automatically. This feature was utilised for all dichotomous questions or for questions with multiple response options that required only one answer to be selected.

For questions that required numerical input, the text field feature was utilised to allow respondents to type in an answer in a number format. For example, where question two asked respondents' current age, the text field feature was applied to an inserted text box, with a number format category selected and field value validation range restrictions applied to ensure a valid age in the range of 18 to 100 years was entered.

If an invalid response was entered, a pop-up message was created that would be displayed informing the respondent as to why the response was invalid. When a valid response was entered, the respondent was automatically progressed to the next question.

Respondents could tab between questions or use the mouse to click on to the next question. A save button feature with an automatic action to execute a function (save, file as) was added to each page to enable respondents to save the document if they needed to stop during their completion of the questionnaire.

Pilot testing

The questionnaire instrument was pilot tested by two intensive care clinicians who were selected by the primary investigator (PTH) due to their similarity to the intended study population. The pilot testers were provided with specific instructions by the primary investigator for the completion of the pilot testing activity. They were asked to complete the questionnaire in full, taking note of the time taken for completion. They were requested to provide comments on what they believed each question was asking and to provide feedback on the clarity and wording of individual questions, and overall readability.

If any difficulties were encountered completing the questionnaire, including with the function of the editable form fields, they were asked to provide specific information on these difficulties. They were asked to go back and re-check response option buttons to ensure they were active and had recorded their responses correctly. They were asked to test the save function feature by saving and exiting their questionnaire and returning to ensure it had saved their input correctly.

The responses and feedback from the pilot testers were reviewed by the primary investigator, with questions and formatting modified according to the feedback received to improve clarity, readability and usability. One iteration of pilot testing was completed.

Sampling frame and survey population

The intended target population for this study was clinicians working in intensive care medicine in any country throughout the world. The sampling frame included all subscribing members of an international e-mail discussion group focussed on intensive care medicine run

by the University of Pittsburgh.[105] The Critical Care Medicine e-mail list (CCM-L) is a free, multidisciplinary electronic-mail discussion group serving multinational subscribers, which has been actively running since 1994. Permission to utilise the e-mail subscribers list for the conduct of the study was obtained from Professor David Crippen, the CCM-L founder and moderator.

Sample size

In 2002, a survey of CCM-L users was conducted with an overall response rate of 72% (452/624 members).[105] In May 2015, at the time of submission of ethics approval to conduct this study, CCM-L membership had increased to over 1,000 active participants.

The standard formulae for a simple random sample was used to calculate the sample size for this study:[97]

$$n = 4P(1-P)/L^2$$

Estimating the *appropriate use* of research evidence is a key goal of this project, and can be used to drive sample size estimates. Given *appropriate use* by Australian and New Zealand intensive care specialists was estimated at 68.22% (P) in the survey by Heighes and Doig,[104] it is reasonable to estimate similar rates amongst international clinicians. The above formula indicates that 88 respondents (n) would be required to obtain reasonable accuracy (L = 10%) in the estimate of appropriate use.

Electronic mail recruitment procedure

Initial contact was made with all subscribing members of CCM-L in August 2015 through the distribution of a generic recruitment e-mail which outlined the purpose of the study and requested volunteers to participate. Contact details (e-mail address) for the study investigators (PTH and GSD) were included at the end of the recruitment e-mail.

A cover letter and participant information statement document that outlined the purpose of the project, along with assurances of confidentiality and anonymity was attached

as a PDF file to the recruitment e-mail to enable subscribing members of CCM-L to read in detail about the project and make an informed decision about participation. Appendix D contains the cover letter and participant information statement as approved by the University of Sydney Human Research Ethics Committee.

Potential participants were requested to make contact with the study investigators via e-mail to indicate their interest in the study.

On receipt of an expression of interest to participate, the participants were e-mailed a study questionnaire.

Follow up mail outs

Following the initial recruitment e-mail to the CCM-L, follow-up reminder e-mails were sent out once a month for a period of one year until August 2016. E-mails were sent at irregular times (e.g. weekdays, weeknights and weekends) in order to capture a range of participants who may access the CCM-L e-mails at varied times around the world.

Maintenance of anonymity and return of questionnaire process

In order to maintain the confidentiality and anonymity of the subscribing members of the CCM-L who volunteered to participate in this study, a web-based drop box was set up on a secure, encrypted University of Sydney research web site: https://research.evidencebased.net/dropbox. This server is physically located at the University of Sydney's Northern Clinical School Intensive Care Research Unit, on campus at the Royal North Shore Hospital, Sydney.

Respondents were provided with instructions regarding how to upload their completed questionnaire to the dropbox at their convenience. A direct link to the drop box was provided to potential participants in the e-mail when the survey package was sent, as well as within the editable questionnaire instrument document. The use of a dropbox enabled a respondent to anonymously upload their questionnaire without revealing any personal details to the

investigators. If the respondent encountered difficulties using the web-based dropbox, they were able to print the questionnaire instrument and complete it manually, then mail back to the investigators via regular postal services. There were no identifying marks on the survey, so use of the dropbox and postal returns were both anonymous.

Data Management

All aspects of data management including data entry, data analysis, verification of data and storage of data, were conducted by the primary investigator (PTH) at the Northern Clinical School Intensive Care Research Unit, located on campus at the Royal North Shore Hospital, Sydney. Data was entered into a custom Excel spreadsheet created using Microsoft Office[j] software.

Following initial entry of the data, accuracy checks were conducted by the primary investigator on database entry, with clear errors and out of range mistakes corrected to the paper source record. On completion of database cleaning by the primary investigator a colleague from the Northern Clinical School Intensive Care Research Unit who was not involved in the conduct of the project conducted an audit of the accuracy of data transcription by comparing fifty percent of all database entries directly to the paper source documents.

Statistical analysis

Quantitative data was presented using descriptive statistics. Because most responses to balanced Likert scales demonstrate Normal distributions, results are reported as mean and standard deviation (SD),[99] or rates with numerator and denominator when appropriate. Ninety-five percent confidence intervals were reported where appropriate. All calculations were conducted using SAS Version 6.2[k].

---

[j] Microsoft Corporation, Redmond, WA, USA.
[k] SAS Institute, Cary, NC, USA.

Aim 6: To conduct an intervention to determine whether an evidence summary tool can improve the use of published research evidence to support clinical decision making.

Before-and-after evaluation of a case-based scenario

To determine whether an *evidence summary tool* can improve the use of published research evidence to support clinical decision making, a case-based scenario evaluation was designed. The international cohort of intensive care clinicians who volunteered to participate in the online questionnaire survey on attitudes towards research evidence were also presented with the case-based scenario evaluation of the evidence summary tool. Using a before-and-after design, *a change in belief in the benefit* of the clinical intervention summarised in the evidence summary tool for the patient described in the case-based scenario was assessed.

Study items

Study items created to address this specific Aim included the *evidence summary* tool and a *case-based scenario* relevant to the clinical intervention described in the evidence summary tool. The case-based scenario was developed to provide a realistic example of a patient typically cared for in an intensive care unit with the primary condition for which the intervention summarised in the evidence summary tool would be of benefit.

Case-based scenario

The case-based scenario was developed by the two study investigators (PTH and GSD) who designed the evidence summary tool. The case described in the scenario was chosen to reflect a patient who clearly met the eligibility criteria of the key RCT[5] demonstrating benefits from the clinical intervention described in the evidence summary tool. The clinical content of the case-based scenario was reviewed for accuracy by two intensive care clinicians not involved in the conduct of the study.

Evaluation

Study participants were presented with the case-based scenario and then asked to indicate their strength in belief of benefit to this specific patient with regards to the clinical intervention described in the evidence summary tool. Participants were also asked to indicate their strength in belief of benefit attributable to five other clinical interventions that may or may not have been appropriate for the patient in the case-based scenario. Clinicians ranked their agreement with the statement '*I believe this patient may benefit from* [intervention name]' with response options presented on a five point balanced Likert scale, ranging from *strongly disagree* to *strongly agree*.

Immediately following this initial exposure to the case-based scenario, respondents were presented with the evidence summary tool and were instructed to carefully read the tool and consider the evidence presented.

After reading the evidence summary tool, the participants were presented with the same case-based scenario, and again asked to rank the strength of their belief with a series of statements regarding the same clinical interventions evaluated in the *before* phase.

Change in belief of benefits

The primary outcome, change in belief of benefit, was assessed using change on response to the five point balanced Likert scale. The original response options ranged from *strongly disagree*, *disagree*, *neutral*, *agree* or *strongly disagree*.

Statistical analysis

Because most responses to balanced Likert scales demonstrate Normal distributions, results are reported as mean and standard deviation (SD).[99] Ninety-five percent confidence intervals were reported where appropriate.

The statistical significance of a *change in beliefs* was assessed using a paired t-test. A P-value less than 0.05 was accepted to identify *statistical significance.* A P-value less than

0.10, but greater than or equal to 0.05 was accepted to identify a *trend* towards statistical significance. All analysis was conducted using SAS Version 6.2[1].

Aim 7: To evaluate competing versions of the evidence summary tool to determine whether specific elements of presentation of the tool can enhance the use of published research evidence to support clinical decision making.

Although expert methodologists consistently create evidence hierarchies that rank Systematic Reviews higher than RCTs as trustworthy sources of research evidence to guide clinical practice,[52-57] clinicians report they read or use systematic reviews infrequently,[34-36, 39, 44, 51, 68] or clinicians identified a preference for RCTs over systematic reviews and meta-analyses.[104] Because of this divergence, we hypothesised that an evidence summary tool that highlights the results from RCTs may perform differently to an evidence summary tool that highlights results from systematic reviews.

Competing versions of evidence summary tools

In order to evaluate this subtle difference, a clinical intervention was identified that was supported by significant benefit demonstrated in an RCT and significant benefit demonstrated in a systematic review. The comparison between these competing primary sources of evidence was undertaken by developing two alternate formats of presentation of the evidence summary tool. The two formats of the evidence summary tool were designed to be identical in all sections, except for the way in which the primary source of research evidence that supported the clinical intervention was cited and highlighted.

Methods for evaluation

The international cohort of intensive care clinicians who volunteered to participate in the online questionnaire survey on attitudes towards research evidence were also presented with the case-based scenario evaluation of the evidence summary tool. Upon providing

---

[1] SAS Institute, Cary, NC, USA.

consent, participants were randomly allocated to receive an evidence summary tool emphasising RCTs or an evidence summary tool emphasising systematic reviews as the source evidence.

Study participants were presented with the case-based scenario and then asked to indicate their strength in belief of benefit to this specific patient with regards to the clinical intervention described in the evidence summary tool. Participants were also asked to indicate their strength in belief of benefit attributable to five other clinical interventions that may or may not have been appropriate for the patient in the scenario. Clinicians ranked their agreement with the statement '*I believe this patient may benefit from* [intervention name]' with response options presented on a five point balanced Likert scale, ranging from *strongly disagree* to *strongly agree*.

Immediately following this initial exposure to the case-based scenario, respondents were presented with the evidence summary tool and were instructed to carefully read the tool and consider the evidence presented.

After reading the evidence summary tool, the participants were presented with the same case-based scenario and again asked to rank the strength in belief of benefit with a series of statements regarding the same clinical interventions evaluated in the before phase.

Differences in belief of benefits

The primary outcome, difference in belief of benefit between the two randomly allocated groups, was assessed using the *differences* in response to the five point balanced Likert scale. The response options ranged from *strongly disagree*, *disagree*, *neutral*, *agree* or *strongly disagree.*

Sample Size

The primary outcome was assessed using a five point balanced Likert scale, with response options ranging from *strongly disagree, disagree, neutral, agree* to *strongly disagree*

Data from previous surveys of intensive care clinicians' attitudes towards using different types of evidence sources to support clinical decision making revealed common standard deviations (SD) of approximately 0.9 on this five point balanced Likert scale.[104]

Using standard sample size formula, with an SD of 0.9, 70 respondents were required per evidence summary tool group in order to achieve 90% power to detect a 0.5 unit difference in our primary outcome: strength of belief in the reported benefits.

Previous research has demonstrated that an effect equal to ½ the SD of the response scale is accepted by clinicians to represent a 'meaningful difference' in many qualitative aspects of health status.[106]

Randomisation methods

SAS Version 6.2[m] was used to computer generate the simple randomisation sequence. Allocation concealment was maintained by not revealing the sequence before consent to participate was obtained. After consent was obtained, the participant was allocated to receive an evidence summary tool that emphasised RCTs or an evidence summary tool that emphasised systematic reviews as determined by the computer generated sequence.

Statistical analysis

The primary outcome, differences in belief of benefit between the two randomly allocated groups, was assessed using a standard t-test on univariable analysis. Multivariable analysis was also conducted to control for potential confounding due to baseline imbalance.

Baseline imbalance was assessed using t-tests or chi-square tests, where appropriate. If group size for any cell for a chi-square test was less than five, Fisher's Exact Test was calculated. A variable was considered to be a potential confounder due to baseline imbalance if the between group univariable P-value was less than 0.10. All potential confounders were included in a multivariable least-squares regression model, that was refined using backwards

---

[m] SAS Institute, Cary, NC, USA.

stepwise elimination. At each elimination step, a P-value was calculated for each variable in the model, and the variable with the highest P-value was eliminated from the model. All P-values were re-calculated for all variables remaining in the model. This process was continued until all remaining P-values were less than 0.05.

A P-value less than 0.05 from an appropriate statistical test was accepted to identify *statistical significance.* A P-value less than 0.10, but greater than or equal to 0.05, from an appropriate statistical test was accepted to identify a *trend* towards statistical significance. All analysis was conducted using SAS Version 6.2[tm].

Aim 8: To investigate whether clinician-level factors, research experience, characteristics of research use and research attitudes predict the likelihood of practice change in response to using an evidence summary tool.

Least-squares regression model development

The primary outcome for this analysis was the variable change in belief of benefit, assessed using change on response to a five point balanced Likert scale.

The purpose of this undertaking was to identify clinician-level factors and characteristics of research evidence that are *independently associated* with change in belief of benefit. To this end, a multivariable least-squares regression model was developed.

Univariable least-squares regression was undertaken to identify clinician-level factors and characteristics of research papers that would qualify for inclusion in the *maximum model*.

Clinician-level factors or characteristics of research papers with a univariable P-value less than 0.10 were included in the *maximum model*.[100] Backwards stepwise elimination was used to identify variables for removal from the maximum model. At each step, a P-value was calculated for each variable in the model, and the variable with the highest P-value was eliminated from the model. All P-values were re-calculated for all variables remaining in the model. This process was continued until all remaining P-values were less than 0.05.[101]

A clinician-level factor or characteristic of a research paper was declared to be significantly and independently associated with change in belief of benefits if it remained in the final multivariable model and had a P-value of <0.05.[102] All analysis was conducted using SAS Version 6.2[n].

---

[n] SAS Institute, Cary, NC, USA.

RESULTS

Aim 1 : To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst intensive care specialists in Australia and New Zealand.

Quantitative mail-out questionnaire survey design

The questionnaire included a total of 31 closed ended questions divided into five structured sections.

The first section of the questionnaire was titled *Demographics* and addressed items related to year of registration as an intensive care specialist, gender and age.

Section two addressed *Research experience* and included items related to experience and participation in research activities, continuing medical education time, computer usage, formal research qualifications and training in evidence-based medicine.

In section three, *Research knowledge*, true or false technical statements were presented to test respondents' knowledge of research terminology and methods. Respondents were required to select from three fixed responses (incorrect, not sure or correct) to indicate their understanding of each knowledge statement.

The fourth section, *Research attitudes,* included six statements related to beliefs and attitudes regarding published research evidence, with respondents asked to select the most appropriate answer from a balanced five point Likert item response scale (strongly disagree, disagree, neutral, agree, strongly agree).

The fifth section, *Research use,* contained questions that collected details of patterns of research use in clinical practice and other job related activities and characteristics of research evidence that may influence or inhibit use.

The final format of the questionnaire along with the complete wording of all questions in each section can be seen in Appendix C.

Pilot testing

The two pilot testers identified that questions with multiple categories presented running cross the page were difficult to read. To improve readability, all questions with multiple categories were re-formatted so they sequenced down the page.

The use of two different response scales within a questionnaire was identified as confusing by the pilot testers. Based upon this feedback, a five point Likert scale was chosen by the study investigators as the most appropriate scale, and questions with continuous rating response scales were re-formatted to be presented with five point Likert response scales.

Response rate

A total of 238 potential respondents were mailed questionnaires. With 133 questionnaires returned to the study investigators, an overall unit response rate of 55.9% (133/238) was achieved. This response rate was achieved through the conduct of three direct mail outs.

Following the initial mail out on 17th of January 2011, 30.3% (72/238) of questionnaires were returned to the investigators. On February 18th 2011, a second mail out was conducted with 165 follow up survey packages mailed to non-responders. Of these 165 second mail out questionnaires 10.3% (17/165) were returned. On the 28th of March 2011, 148 follow up survey packages were mailed to non-responders in the third mail out, with 28.4% (42/148) of these questionnaires returned.

After verbal promotion of the study at the annual College of Intensive Care Medicine (CICM) conference (held on the 3rd to 5th June 2011) an additional two questionnaires were returned. The final response was received in June 2011, following which the survey was closed out.

Missing items

One questionnaire from the 133 questionnaires returned to the investigators was completely blank with an open text note appended stating "I'm retired, please don't bother me again!"

Overall incomplete data at the question item level was 2.8% (286 missing values from 133 returned surveys with 77 question items on each survey). Missing values for individual question items ranged from 0.8% (1/133) missing to 13.5% (18/133) missing.

Full details of item response rates for each individual question are reported in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11 and Table 12.

Responses

Demographics

The mean age of respondents was 51.20 (SD 8.57) years with males making up 81.5% (106/130) of the responding population. Respondents had practised as a registered Intensive Care Specialist for a mean of 12.60 (SD 7.00) years. See Table 4 for complete details.

Research experience

Fifty-five percent (72/129) of respondents reported holding an academic appointment at a university. The weekly mean time devoted to continuing medical education was 6.80 (SD 4.39) hours per respondent, with *daily* internet use reported by 97.7% (128/131). Formal research training was reported by 31.3% (41/131) of respondents, whilst 40.8% (53/130) of respondents reported formal training in evidence-based medicine.

Respondents reported participation in research activities in the clinical area, with 87.8% (115/131) indicating they had *consented a patient for enrolment in a clinical trial* and 47.3% (62/131) indicating *involvement in the running of funded clinical trials*. Additional details regarding *Research experience* can be found in Table 5.

Research knowledge

The mean research knowledge score was 2.95 (SD 1.70) correct responses from six research knowledge questions. The question most commonly answered correctly was question number 17, with 96.2% (125/130) of respondents able to identify that the statement "*Conventionally, results in a clinical trial are considered to be statistically significant (i.e. unlikely to have arisen by chance) if the P-value is less than 0.05 (p<0.05)*" was true.

The question most commonly answered incorrectly was question number 18, with only 14.7% (19/129) of respondents able to correctly identify that the statement "*In a meta-analysis, the I^2 metric is a measure of heterogeneity that is dependent on the number of patients included in a trial*" was true.

Table 6 lists complete details of all six knowledge statements, item response rates and the number of respondents identifying the correct response for each question.

Research attitudes

Positive feelings (*agree* or *strongly agree*) towards using published research evidence in clinical practice were reported by 65.4% (85/130) of respondents, and 75.4% (98/130) of respondents also reported that their colleagues had positive feelings (*agree* or *strongly agree*) towards using published research evidence in clinical practice.

Eighty-six percent (112/130) of respondents reported positive feelings (*agreed* or *strongly agreed*) towards using the results of an RCT to guide their clinical practice, whereas 59.2% (77/130) of respondents reported positive feelings towards using the results of a systematic review to guide their clinical practice (*agreed* or *strongly agreed*).

Table 7 lists complete details of all *Research attitude* statements.

Research use

Ninety-six percent (126/130) of respondents reported they used the concepts of evidence-based medicine in their own clinical practice *at least sometimes,* which was defined as 'every month or so'.

With regards to the *frequency of reading* different types of research evidence, 97.7% (127/130) of respondents reported they read RCTs *at least sometimes,* whereas 65.1% (84/129) of respondents reported they read *information in the Cochrane library at least sometimes*. Complete details regarding frequency of reading specific types of research evidence are reported in Table 8.

In a question regarding *frequency of using* different types of research evidence *to guide clinical practice*, Published Evidence Based Guidelines were used by 96.9% (126/130) of respondents *at least sometimes* whereas 67.7% (88/130) of respondents reported using *information in the Cochrane Library* to guide clinical decisions *at least sometimes*. Complete details regarding patterns of use of research evidence are reported in Table 9 and Table 10.

Respondents were given a list of statements describing factors that may *help* their decision to use the results of published research evidence to change clinical practice and asked to rank how often they found these factors helpful. One hundred percent (129/129) of respondents rated *'the results have clear benefit to my patients'* as *helpful at least sometimes* whereas *'the paper presents a full economic analysis'* was rated as *helpful at least sometimes* by 62.0% (80/129) of respondents. Complete details reported in Table 11

When presented with a list of statements describing factors that may *inhibit* their use of research evidence, 56.9% (74/130) of respondents *agreed or strongly agreed* with the statement '*I have difficulty finding the time to read*'. Ten percent (13/129) of respondents *agreed* or *strongly agreed* with the statement *'appraising published research papers is not part of my role'*. Table 12 provides complete responses to this item.

Table 4. Demographics

Variable	Response Rate (n/N)[&]	Result
Q1. Years practising as a Registered Intensive Care Specialist, mean (SD)	127/133	12.60 (7.00)
Q2. Gender - male, percent (n/N)	130/133	81.5% (106/130)
Q3. Age in years, mean (SD)	129/133	51.20 (8.57)

SD – standard deviation; n/N – number of reported events/Number of responses; *n/N*[&] item response rate/unit response rate

Table 5. Research experience

Variable	Responses $(n/N)^{\&}$	Percent
Q4. Level of training or qualification in research[*]	131/133	
Research Fellowship[*]	12/131	9.1%
Formal Research Methodology Course[*]	11/131	8.4%
Graduate Level Research Methodology Course[*]		
Graduate Certificate		0
Graduate Diploma	6/131	4.6%
Masters	8/131	6.1%
PhD	15/131	11.5%
No formal research qualification	90/131	68.7%
Q5. Level of training or qualification in EBM[#]	130/133	
Have attended a non-university based EBM course or workshop[#]	47/130	36.2%
Have attended a University based EBM course or workshop[#]	14/130	10.8%
Have attended a McMaster University EBM course or workshop[#]		0
No formal EBM training	77/130	59.2%
Q6. Academic appointment held at a university, percent (n/N)	72/129	55.8%
Q7. Have you ever published any research papers as a named contributing or primary author?	101/131	77.1%
Q8. Are you involved in the running of any funded clinical trials?	62/131	47.3%
Q9. Have you ever consented a patient for a clinical trial?	115/131	87.8%
Q10. Are you or have you been named as an investigator on an ethics submission for a funded clinical trial?	88/131	67.2%
Q11. Weekly CME hours, mean (SD)	132/133	6.80 (4.39)
Q12. Frequency of internet use: percent (n/N)	131/133	
Daily	128/131	97.7%
At least weekly	3/131	2.3%
Less than weekly		0%
Never		0%
Q13. Use a computer for the purposes of: percent (n/N)	131/133	
Word processing	125/131	95.4%
Data analysis	69/131	52.7%
Search databases for published papers	122/131	93.1%
Other	108/131	82.4%

PhD – Doctor of Philosophy; EBM – Evidence Based Medicine; CME – continuing medical education; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses

*respondents able to select more than one level of training or qualification in research

#respondents able to select more than one level of training or qualification in EBM

&respondents able to select more than one purpose for using a computer

Table 6. Research Knowledge

Variable (Question number, knowledge statement and correct answer)	Correct Response (n/N)$^{\&}$	Percent
Q14. The CONSORT Statement is an international guidance document intended to improve the reporting of RCT's. **(True)**	79/130	60.8%
Q15. Allocation concealment refers to the act of masking which treatment a patient enrolled in a clinical trial is currently receiving from the treating clinician. **(False)**	39/129	30.2%
Q16. The PRISMA Statement is an international guidance document intended to address the suboptimal reporting of systematic reviews and meta-analyses of RCTs. **(True)**	58/129	45.0%
Q17. Conventionally, results in a clinical trial are considered to be statistically significant (i.e. unlikely to have arisen by chance) if the P-value is less than 0.05 (p<0.05). **(True)**	125/130	96.2%
Q18. In a meta-analysis, the I^2 metric is a measure of heterogeneity that is dependent on the number of patients included in a trial. **(True)**	19/129	14.7%
Q19. The forest plot is a graph used in a meta-analysis to detect publication bias in which the estimate of risk is plotted against sample size. **(False)**	60/129	46.5%
Average score out of 6 (SD)		**2.95 (1.70)**

CONSORT - Consolidated Standards of Reporting Trials; RCTs – randomised controlled trials; PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses; *n/N*$^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses

Table 7. Research attitudes

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

Variable (Question number)	Response Rate $(n/N)^\&$	Respondents selecting each response category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q20. Positive feelings towards EBM*	130/133	2.3 (3/130)	16.9 (22/130)	15.4 (20/130)	55.4 (72/130)	10.0 (13/130)	3.53 (0.97)
Q21. Colleagues positive feelings towards EBM*	130/133	1.5 (2/130)	3.9 (5/130)	18.5 (24/130)	66.9 (87/130)	8.5 (11/130)	3.78 (0.72)
Q22. Positive feelings towards using RCTs to guide clinical practice*	130/133	0 (0/130)	2.3 (3/130)	11.5 (15/130)	76.2 (99/130)	10.0 (13/130)	3.94 (0.55)
Q23. Positive feelings towards using systematic review/ meta-analysis to guide clinical practice*	130/133	1.5 (2/130)	11.5 (15/130)	27.7 (36/130)	54.6 (71/130)	4.6 (6/130)	3.49 (0.82)
Q24. Time limitations restrict the incorporation of EBM into my clinical practice*	130/133	9.2 (12/130)	43.1 (56/130)	20.8 (27/130)	24.6 (32/130)	2.3 (3/130)	2.68 (1.02)
Q25. Research evidence has not made a difference to my clinical practice*	130/133	36.9 (48/130)	54.6 (71/130)	6.2 (8/130)	1.5 (2/130)	0.8 (1/130)	1.75 (0.71)

EBM – Evidence Based Medicine; RCT's – Randomised Controlled Trials; $n/N^\&$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Summary of question only, for complete wording of questions see Appendix C.

Table 8. Frequency of research use

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item)	Response Rate $(n/N)^{\&}$	Respondents selecting each response category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q26. How often do you use the concepts of EBM in your clinical practice?	130/133	0 (0/130)	3.1 (4/130)	23.9 (31/130)	51.5 (67/130)	21.5 (28/130)	3.92 (0.76)
Q27: How often do you read the following:							
Published RCTs	130/133	0 (0/130)	2.3 (3/130)	32.3 (42/130)	55.4 (72/130)	10.0 (13/130)	3.73 (0.67)
Published EBGs	130/133	0 (0/130)	10.8 (14/130)	45.4 (59/130)	40.8 (53/130)	3.1 (4/130)	3.36 (0.72)
Textbooks	130/133	3.1 (4/130)	13.1 (17/130)	42.3 (55/130)	33.9 (44/130)	7.7 (10/130)	3.30 (0.90)
Published Meta-analyses	130/133	1.5 (2/130)	14.6 (19/130)	51.5 (67/130)	30.8 (40/130)	1.5 (2/130)	3.16 (0.75)
Information in Cochrane Library	129/133	4.6 (6/130)	30.0 (39/130)	48.5 (63/130	12.3 (16/130)	3.9 (5/130)	2.81 (0.86)

EBM – Evidence Based Medicine; RCTs – Randomised Controlled Trials; EBGs – Evidence Based Guidelines; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

127

Table 9. Types of research used

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item) Listed in order from most highly ranked	Response Rate $(n/N)^{\&}$	Respondents selecting each response category Percent (n/N)					Mean score (SD)
		1	2	3	4	5	
Q28. How often do you use the following information sources to guide decisions in your clinical practice?							
Published EBGs	130/133	0 (0/130)	3.1 (4/130)	43.1 (56/130)	46.1 (60/130	7.7 (10/130	3.58 (0.68)
Results of an RCT	129/133	0 (0/129)	5.4 (7/129)	41.1 (53/129	47.3 (61/129)	6.2 (8/129)	3.54 (0.70)
Advice given by colleague	130/133	0 (0/130)	6.9 (9/130)	50.8 (66/130)	34.6 (45/130)	7.7 (10/130)	3.43 (0.74)
Textbook information	129/133	0 (0/130)	14.0 (18/129)	51.9 (67/129)	30.2 (39/129)	3.9 (5/129)	3.24 (0.77)
Conference presentations	130/133	0 (0/130)	20.0 (26/130)	47.7 (62/130)	28.5 (37/130)	3.9 (5/130)	3.16 (0.79)
Results of a Meta-analysis	130/133	2.3 (3/130)	23.9 (31/130)	47.7 (62/130)	23.1 (30/130)	3.1 (4/130)	3.01 (0.83)
Information from Google search	130/133	3.9 (5/130)	26.2 (34/130)	41.5 (54/130)	23.1 (30/130)	5.4 (7/130)	3.00 (0.93)
Evidence summary journals	129/133	8.5 (11/129)	28.7 (37/129)	39.5 (51/129)	17.8 (23/129)	5.4 (7/129)	2.83 (1.00)
Results of Cochrane review	130/133	3.1 (4/130)	29.2 (38/130)	53.1 (69/130)	13.9 (18/130)	0.8 (1/130)	2.80 (0.74)

EBGs – Evidence Based Guidelines; RCTs – Randomised Controlled Trials; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 10. Situations where research is used

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item) Listed in order from most highly ranked	Response Rate $(n/N)^{\&}$	Respondents selecting each response category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q29: How often do you use published research evidence in the following situations?							
Preparing a presentation for colleagues	129/133	0 (0/129)	4.7 (6/129)	30.2 (39/129)	48.8 (63/129)	16.3 (21/129)	3.77 (0.76)
Preparing a teaching session for trainees	129/133	0 (0/129)	3.9 (5/129)	32.6 (42/129)	48.1 (62/129)	15.5 (20/129)	3.75 (0.76)
Improving my knowledge	130/133	0 (0/130)	3.1 (4/130)	29.2 (38/130)	58.5 (76/130)	9.2 (12/130)	3.74 (0.67)
Developing guidelines or protocols	129/133	0.8 (1/129)	11.6 (15/129)	30.2 (39/129)	43.4 (56/129)	14.0 (18/129)	3.58 (0.90)
Making individual patient care decisions	128/133	0 (0/128)	7.8 (10/128)	39.1 (50/128)	43.0 (55/128)	10.2 (13/128)	3.55 (0.78)
Settling clinical dispute re patient management	128/133	1.6 (2/128)	15.6 (20/128)	45.3 (58/128)	32.0 (41/128)	5.5 (7/128)	3.24 (0.84)
Reviewing management of a past patient (eg M&Ms)	129/133	0.8 (1/129)	10.9 (14/129)	58.9 (76/129)	25.6 (33/129)	3.9 (5/129)	3.21 (0.71)
Preparing to provide information to patient / NOK	129/133	3.9 (5/129)	36.4 (47/129)	39.5 (51/129)	20.2 (26/129)	0 (0/129)	2.76 (0.82)

M&M – morbidity and mortality meetings; NOK – next of kin; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 11. Factors that *help* the use of research to change practice

Variable (Question and response item) Listed in order from most highly ranked	Response Rate (n/N)[&]	Respondents selecting each response category * Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q30: How often are the following factors likely to help your decision to use the results of published research evidence to change practice?							
The results have clear benefit to my patients	129/133	0 (0/129)	0 (0/129)	2.3 (3/129)	58.9 (76/129)	38.8 (50/129)	4.36 (0.53)
The project was methodologically sound, with no major flaws	129/133	0 (0/129)	0 (0/129)	8.5 (11/129)	62.8 (81/129)	28.7 (37/129)	4.20 (0.58)
The intervention is described in enough detail so that I could implement it in my clinical practice	128/133	0 (0/128)	15.6 (2/128)	11.7 (15/128)	58.6 (75/128)	28.1 (36/128)	4.13 (0.67)
The paper fully explored all the possible benefits and harms	129/133	0 (0/129)	0.8 (1/129)	12.4 (16/129)	65.9 (85/129)	20.9 (27/129)	4.07 (0.60)
The project included a lot of patients	128/133	0 (0/128)	0.8 (1/128)	17.2 (22/128)	62.5 (80/128)	19.5 (25/128)	4.01 (0.63)
I understand the pathophysiological rationale of the intervention	129/133	0 (0/129)	2.3 (3/129)	18.6 (24/129)	55.0 (71/129)	24.0 (31/129)	4.01 (0.72)
The paper was clearly written (i.e. concise, coherent, to the point, logical)	128/133	0 (0/128)	0 (0/128)	14.8 (19/128)	71.1 (91/128)	14.1 (18/128)	3.99 (0.54)
The paper is the second publication on this topic to demonstrate a significant benefit to patients	129/133	0.8 (1/129)	2.3 (3/129)	23.3 (30/129)	55.0 (71/129)	18.6 (24/129)	3.88 (0.76)
The project involved multiple study centres	129/133	0 (0/129)	3.9 (5/129)	27.1 (35/129)	50.4 (65/129)	18.6 (24/129)	3.84 (0.77)
Other Intensivists have changed practice based on this paper	129/133	0 (0/129)	9.3 (12/129)	34.1 (44/129)	41.1 (53/129)	15.5 (20/129)	3.63 (0.86)
The project was conducted in my own health care system	129/133	4.7 (6/129)	11.6 (15/129)	29.5 (38/129)	42.6 (55/129)	11.6 (15/129)	3.45 (1.00)
The results will reduce costs but patient outcomes will not be compromised	129/133	1.6 (2/129)	15.5 (20/129)	39.5 (51/129)	38.8 (50/129)	4.7 (6/129)	3.29 (0.84)

[#] *table continued over page*

		1.6	20.2	34.9	39.5	3.9	
The paper was written by a recognised expert in the field	129/133	1.6 (2/129)	20.2 (26/129)	34.9 (45/129)	39.5 (51/129)	3.9 (5/129)	3.24 (0.87)
The CONSORT or QUOROM statements were followed	115/133	9.6 (11/115)	9.6 (11/115)	42.6 (49/115)	28.7 (33/115)	7.8 (9/115)	3.10 (1.04)
I have seen the author present the findings of the project at a conference	128/133	2.3 (3/128)	27.3 (35/128)	39.1 (50/128)	25.0 (32/128)	5.5 (7/128)	3.02 (0.92)
The paper presents a full economic analysis	129/133	7.0 (9/129)	31.0 (40/129)	37.2 (48/129)	22.5 (29/129)	2.3 (3/129)	2.82 (0.94)

CONSORT - Consolidated Standards of Reporting Trials; QUOROM - Quality of Reporting of Meta-analyses; *n/N*[&] item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

* **Response options:** *Never helps* (Score 1); *Rarely helps* (Score 2); *Sometimes helps* (Score 3); *Often helps* (Score 4); *Very often helps* (Score 5).

Table 12. Factors that *inhibit* the use of research in clinical practice

Variable	Response Rate *(n/N)*[&]	Responses to each category * Percent (n/N)					Mean score (SD)
		1	2	3	4	5	
Q31: The following factors *inhibit* my use of published research evidence in clinical practice							
I believe there is a lack of good evidence providing meaningful answers to my clinical problems.	129/133	1.6 (2/129)	10.9 (14/129)	31.0 (40/129)	45.0 (58/129)	11.6 (15/129)	3.54 (0.89)
Individual patient variation is not accounted for in the results of published research.	128/133	1.6 (2/128)	20.3 (26/128)	25.8 (33/128)	42.2 (54/128)	10.2 (13/128)	3.39 (0.97)
I have difficulty finding the time to read.	130/133	3.1 (4/130)	19.2 (25/130)	20.8 (27/130)	50.0 (65/130)	6.9 (9/130)	3.38 (0.98)
I can find papers using MEDLINE, but it is difficult to find key papers good enough to guide my practice.	130/133	5.4 (7/130)	29.2 (38/130)	20.8 (27/130)	37.7 (49/130)	6.9 (9/130)	3.12 (1.08)
I do not trust observational studies enough to use them to guide my practice.	129/133	6.2 (8/129)	27.1 (35/129)	35.7 (46/129)	26.4 (34/129)	4.7 (6/129)	2.96 (0.99)
I do not have enough training in EBM.	130/133	8.5 (11/130)	30.8 (40/130)	30.8 (40/130)	25.4 (33/130)	4.6 (6/130)	2.87 (1.04)
I have difficulties convincing my hospital to stock new drugs.	129/133	7.0 (9/129)	37.2 (48/129)	29.5 (38/129)	23.3 (30/129)	3.1 (4/129)	2.78 (0.98)
I have difficulties critically appraising papers.	130/133	11.5 (15/130)	35.4 (46/130)	26.9 (35/130)	24.6 (32/130)	1.5 (2/130)	2.69 (1.02)
I have insufficient authority to introduce some new practices into my hospital.	129/133	10.1 (13/129)	41.9 (54/129)	20.2 (26/129)	25.6 (33/129)	2.3 (3/129)	2.68 (1.04)
My colleagues do not support me when I am the first to change my own practice using new research evidence.	129/133	7.8 (10/129)	44.2 (57/129)	34.9 (45/129)	11.6 (15/129)	1.6 (2/129)	2.55 (0.86)
I have difficulties using MEDLINE.	130/133	19.2 (25/130)	46.2 (60/130)	14.6 (19/130)	16.2 (21/130)	3.9 (5/130)	2.39 (1.09)
Studies conducted in Europe and the USA do not apply to my patients.	130/133	12.3 (16/130)	53.9 (70/130)	24.6 (32/130)	7.7 (10/130)	1.5 (2/130)	2.32 (0.85)
Appraising published research papers is not part of my role.	129/133	22.5 (29/129)	53.5 (69/129)	14.0 (18/129)	9.3 (12/129)	0.8 (1/129)	2.12 (0.89)

MEDLINE - U.S. National Library of Medicine® premier bibliographic database; EBM – Evidence Based Medicine; USA – United States of America; *n/N*[&] item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation
* Response options: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5)

Aim 2: To assess the level, patterns and characteristics of appropriate use of research evidence in intensive care medicine in Australia and New Zealand using a metric proposed and evaluated by De Vito *et al.*[45]

Appropriate use rates

Items contributing to the calculation of the appropriate use metric

According to the metric proposed by De Vito *et al.*, *appropriate use* of research evidence is defined as *reading* RCTs and systematic reviews *at least sometimes* and *using* RCTs and systematic reviews in clinical practice *at least sometimes*.[45]

Whilst 97.7 % (127/130) of respondents reported *reading* RCTs *at least sometimes,* 93.8% (122/129) of respondents reported *using* RCTs to guide clinical practice *at least sometimes*. Furthermore, 83.8% (109/130) of respondents reported *reading* systematic reviews *at least sometimes,* whilst 73.8% (96/130) reported *using* systematic reviews to guide clinical practice *at least sometimes*. Table 13 shows complete responses for each category to the four key questions used to score appropriate use.

Calculation of appropriate use rate

A total of 129 respondents (N=129) provided complete responses to all four key questions and were eligible for calculation of the *appropriate use* metric. From these 129 respondents, 88 (n) reported they read RCTs *at least sometimes* **and** read systematic reviews *at least sometimes* **and** used RCTs *at least sometimes* **and** used systematic reviews *at least sometimes*. Thus, the overall *appropriate use* rate was 88/129 (68.2%, 95% CI 59.4 to 76.1).

Characteristics of appropriate users vs. non-users

Demographics

There was no significant difference in the age (50.48 vs. 52.12 years, P=0.32), gender (males 82.6% vs. 82.9%, P=0.96) or years practicing intensive care (12.55 vs. 12.74, P=0.89)

of appropriate users compared to non-users. Complete details of demographic characteristics can be seen in Table 14.

Research experience

Significantly more appropriate users reported they had *published a paper as a named contributing or primary author* (72/87 vs. 27/41, P=0.034), *consented a patient for enrolment in a clinical trial* (81/87 vs. 33/41, P=0.034) and had been *involved in the running of funded clinical trials* (51/87 vs. 11/41, P=0.00080). Furthermore, there was a trend towards more appropriate users reporting they had *formal training in evidence-based medicine* (41/87 vs. 12/41, P=0.057). There were no differences in any other aspects of research experience (Table 15).

Research Knowledge

Appropriate users scored significantly higher on the six knowledge questions than non-users (mean score 3.26/6 vs. 2.24/6, P=0.0014). Table 16 lists complete details of all six knowledge statements, item response rates and the number of correct responses by group for each question.

Research attitudes

Appropriate users had significantly stronger positive feelings towards evidence-based medicine (mean score 3.76 vs. 3.05, P<0.0001), significantly stronger positive feelings towards using RCTs to guide clinical practice (mean score 4.01 vs. 3.78, P=0.048) and significantly stronger positive feelings towards using systematic reviews to guide clinical practice (3.80 vs. 2.8, P<0.0001). Appropriate users demonstrated a trend towards stronger disagreement with the statement *research evidence has not made a difference to my clinical practice* (mean score 1.65 vs. 1.93, P=0.055). No other aspects of research attitudes differed between groups (see Table 17 for complete details).

Research use

The responses to the five point balanced Likert scale rating *frequency* were graded such that a score of three equated to the statement *at least sometimes*. The scale ranged from a score of one (*never*) to a score of five (*very often*). Table 18, Table 19 and Table 20 report questions related to frequency of research use. Complete details of the scale can be found in these tables.

Appropriate users reported *using the concepts of EBM in clinical practice* significantly more frequently than non-users (mean score 4.09 vs. 3.54, P<0.0001).

Appropriate users reported *reading* all types of information resources significantly more frequently than non-users: (RCT mean frequency score 3.86 vs. 3.44, P=0.00070; clinical practice guideline frequency score 3.56 vs. 2.95, P<0.0001; textbook frequency score 3.43 vs. 3.00, P=0.029; systematic review frequency score 3.43 vs. 2.56, P<0.0001; Cochrane Library frequency score 3.02 vs. 2.34, P<0.0001). Table 18 reports complete results.

Appropriate users also reported *using* most types of information resources to guide clinical practice significantly more frequently than non-users: (RCT mean frequency score 3.75 vs. 3.24, P<0.0001; clinical practice guideline frequency score 3.75 vs. 3.24, P<0.0001; systematic review frequency score 3.42 vs. 2.10, P<0.0001; Cochrane Library frequency score 3.03 vs. 2.29, P<0.0001). There was a trend towards more frequent use of textbooks to guide clinical practice by appropriate users (frequency score 3.18 vs. 3.06, P=0.099). There was no difference between groups with regards to the frequency of using *advice given by colleagues*, *conference presentations*, *information from a Google search* or *evidence summary journals*. Table 19 lists complete details for this item.

Besides using research evidence to guide clinical practice, *appropriate user*s reported *using published research evidence* significantly more frequently in *teaching sessions for trainees* (mean frequency score 3.85 vs. 3.53, P=0.024), to *improve my knowledge* (mean frequency score 3.92 vs. 3.37, P<0.0001), to *settle a clinical dispute regarding patient*

management (mean frequency score 3.43 vs. 2.86, P=0.0004), for *conducting Mortality and Morbidity rounds* (mean frequency score 3.32 vs. 2.96, P=0.012), and to *prepare to provide information to a patient or patient's family* (mean frequency score 2.89vs. 2.50, P=0.013). There was a trend towards more frequent use of research evidence by appropriate users to *develop guidelines or protocols* (mean frequency score 3.67 vs. 3.38, P=0.086). Complete details for all items related to situations where research evidence is used can be seen in Table 20.

The responses to the five point balanced Likert scale rating factors that might *help research evidence to change practice* were graded such that a score of three equated to the statement *sometimes helps*. The scale ranged from a score of one (*never helps*) to a score of five (*very often helps*). Table 21 reports complete responses to this question and presents complete details of the response scale.

Appropriate users reported that if *a project was methodologically sound, with no major flaws* it was significantly *more likely to help change practice* compared to non-users (mean score 4.32 vs. 3.93, P=0.0003). Furthermore, compared to non-users, appropriate users judged research evidence as significantly more likely to help change practice if the *paper fully explored all possible benefits and harms* (mean score 4.16 vs. 3.88, P=0.013), *included a lot of patients* (mean score 4.08 vs. 3.82, P=0.032), *was clearly written* (mean score 4.10 vs. 3.83, P=0.018), *involved multiple study centres* (mean score 4.02 vs. 3.43, P<0.0001), *was consistent with the CONSORT or QUORUM statements* (mean score 3.10 vs. 2.87, P=0.015), *and presented a full economic analysis* (mean score 3.01 vs. 2.43, P=0.00090).

The responses to the five point balanced Likert scale rating *agreement with statements regarding factors that may inhibit* the use of research evidence were graded such that a score of three equated to *neutral*. The scale ranged from a score of one (*strongly disagree*) to a score of

five (*strongly agree*). Table 22 reports complete responses to this question and presents complete details of the response scale.

Overall, appropriate users demonstrated *less agreement* with statements regarding potential factors that may inhibit the use of research evidence. Compared to non-users, appropriate users reported *significantly weaker agreement* with the statements *individual patient variation is not accounted for in the results of published research* (mean score 3.25 vs. 3.69, P=0.018) and *appraising published research papers is not part of my role* (mean score 1.94 vs. 2.55, P=0.00030). Appropriate users reported a trend towards weaker agreement with the statements *I can find papers using MEDLINE, but it is difficult to find key papers good enough to guide my practice* (mean score 2.99 vs. 3.37, P=0.064), *I have difficulties using MEDLINE* (2.25 vs. 2.63, P=0.057) and *I do not have enough training in EBM* (mean score 2.75 vs. 3.10, P=0.076).

Table 22 provides details of all responses related to this question.

Table 13 Individual responses to key questions used to score appropriate use

Allowable responses: *Never* (1); *Rarely* = once or twice a year (2); *Sometimes* = every month or so (3); *Often* = every week or so (4); *Very often* = every day or so (5).

Variable (Question and response item) Listed in order from most highly ranked	Response Rate $(n/N)^{\&}$	Respondents selecting each response category Percent (n/N)					Mean score (SD)
		1	2	3*	4*	5*	
Q27: How often do you read the following:							
a: Published RCTs	130/133	0 (0/130)	2.3 (3/130)	**32.3** **(42/130)**	**55.4** **(72/130)**	**10.0** **(13/130)**	3.73 (0.67)
e: Published Meta-analyses	130/133	1.5 (2/130)	14.6 (19/130)	**51.5** **(67/130)**	**30.8** **(40/130)**	**1.5** **(2/130)**	3.16 (0.75)
Q28. How often do you use the following information sources to guide decisions in your clinical practice?							
e: Results of an RCT	129/133	0 (0/130)	5.4 (7/130)	**41.1** **(53/129)**	**47.3** **(61/129)**	**6.2** **(8/129)**	3.54 (0.70)
i: Results of a Meta-analysis	130/133	2.3 (3/130)	23.9 (31/130)	**47.7** **(62/130)**	**23.1** **(30/130)**	**3.1** **(4/130)**	3.01 (0.83)

RCTs – randomised controlled trials; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

A response of sometimes (3), often (4) or very often (5) contributed to the appropriate use metric

Table 14. Appropriate users vs. non-users: Demographics

Variable	Appropriate Users (N= 88)	Non-Users (N=41)	P-value
Q1. Years practising as a Registered Intensive Care Specialist, mean (SD)	12.55 (7.42) n=86	12.74 (6.24) n=39	0.89
Q2. Gender - male, percent (n/N)	82.6% (71/86)	82.9% (34/41)	0.96
Q3. Age in years, mean (SD)	50.48 (8.25)	52.19 (9.12)	0.32

n/N – number of reported events/Number of responses; SD – standard deviation

Table 15. Appropriate users vs. non-users: Research experience

Variable	Appropriate Users percent (n/N)	Non-Users percent (n/N)	P-value
Q4. Level of training or qualification in research*			
Research Fellowship*	8.1% (7/87)	12.2% (5/41)	0.45
Formal Research Course*	10.3% (9/87)	4.9% (2/41)	0.31
Graduate Level Research Course*	26.4% (23/87)	14.6% (6/41)	
Graduate Certificate	0% (0/23)	0% (0/6)	
Graduate Diploma	26.1% (6/23)	0% (0/6)	0.22
Masters	26.1% (6/23)	33.3% (2/6)	
PhD	47.8% (11/23)	66.7% (4/6)	
No formal research qualification	66.7% (58/87)	70.7% (29/41)	0.65
Q5. Level of training or qualification in EBM#			
Non-university course or workshop#	39.1% (34/87)	29.3% (12/41)	0.28
University course or workshop#	11.5% (10/87)	9.8% (4/41)	0.77
McMaster University course or workshop#	0	0	
No formal EBM training	52.9% (46/87)	70.7% (29/41)	**0.057**
Q6. Academic appointment held at a university, percent (n/N)	57.0% (49/86)	57.5% (23/40)	0.96
Q7. Have you ever published any research papers as a named contributing or primary author?	82.8% (72/87)	65.9% (27/41)	**0.034**
Q8. Are you involved in the running of any funded clinical trials?	58.6% (51/87)	26.8% (11/41)	**0.00080**
Q9. Have you ever consented a patient for a clinical trial?	93.1% (81/87)	80.5% (33/41)	**0.034**
Q10. Are you or have you been named as an investigator on an ethics submission for a funded clinical trial?	69.0% (60/87)	65.9% (27/41)	0.73
Q11. Weekly CME hours, mean(SD)	7.27 (3.74) n=88	5.83 (5.37) n=41	0.13
Q12. Frequency of internet use: percent (n/N)			
Daily	98.9% (86/87)	95.1% (39/41)	
At least weekly	1.2% (1/87)	4.9% (2/41)	0.20
Less than weekly	0	0	
Never	0	0	
Q13. Use a computer for the purposes of: percent (n/N)&			
Word processing	94.3% (83/88)	95.1% (39/41)	0.94
Data analysis	55.7% (49/88)	43.9% (18/41)	0.19
Search databases for published papers	95.5% (84/88)	87.8% (36/41)	0.057
Other	79.3% (68/87)	88.1% (36/42)	0.44

PhD – Doctor of Philosophy; EBM – Evidence Based Medicine; CME – continuing medical education; n/N – number of reported events/Number of responses
*respondents able to select more than one level of training or qualification in research
#respondents able to select more than one level of training or qualification in EBM
&respondents able to select more than one purpose for using a computer

Table 16. Appropriate users vs. non-users: Research knowledge

Variable (Question number and correct answer)	Appropriate Users percent (n/N)	Non-Users percent (n/N)	P-value
Q14. The CONSORT Statement is an international guidance document intended to improve the reporting of RCT's. **(True)**	69.3% (61/88)	41.5% (17/41)	**0.0027**
Q15. Allocation concealment refers to the act of masking which treatment a patient enrolled in a clinical trial is currently receiving from the treating clinician. **(False)**	33.0% (29/88)	25.0% (10/40)	0.37
Q16. The PRISMA Statement is an international guidance document intended to address the suboptimal reporting of systematic reviews and meta-analyses of RCTs. **(True)**	51.7% (45/87)	29.3% (12/41)	**0.018**
Q17. Conventionally, results in a clinical trial are considered to be statistically significant (ie unlikely to have arisen by chance) if the p value is less than 0.05 ($p<0.05$). **(True)**	98.9% (87/88)	90.2% (37/41)	**0.019**
Q18. In a meta-analysis, the I^2 metric is a measure of heterogeneity that is dependent on the number of patients included in a trial. **(True)**	19.3% (17/88)	12.5% (5/40)	0.35
Q19. The forest plot is a graph used in a meta-analysis to detect publication bias in which the estimate of risk is plotted against sample size. **(False)**	54.6% (48/88)	27.5% (11/40)	**0.0046**
Average score out of 6 (SD)	**3.26 (1.66)**	**2.24 (1.61)**	**0.0014**

CONSORT - Consolidated Standards of Reporting Trials; RCTs – randomised controlled trials; PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses; n/N – number of reported events/Number of responses

Table 17. Appropriate users vs. non-users: Research attitudes

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5)

Variable (Question number)	Appropriate Users (N=88)	Non-Users (N=41)	P-value
	Mean Score (SD)		
Q20. Positive feelings towards EBM*	3.76 (0.86)	3.05 (1.02)	**0.00010**
Q21. Colleagues positive feelings towards EBM*	3.83 (0.73) n=87	3.68 (0.69) n=41	0.29
Q22. Positive feelings towards using RCTs to guide clinical practice*	4.01 (0.49)	3.78 (0.65)	**0.048**
Q23. Positive feelings towards using systematic review/meta-analysis to guide clinical practice*	3.80 (0.61)	2.83 (0.83)	**<0.0001**
Q24. Time limitations restrict the incorporation of EBM into my clinical practice*	2.66 (1.04)	2.68 (0.99)	0.90
Q25. Research evidence has not made a difference to my clinical practice*	1.67 (0.72)	1.93 (0.65)	**0.055**

EBM – Evidence Based Medicine; RCT's – Randomised Controlled Trials; SD – standard deviation

Summary of question only, for complete wording of questions, see Appendix C.

Table 18. Appropriate users vs. non-users: Frequency of research use

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question number and response item)	Appropriate Users (N=88)	Non-Users (N=41)	P-value
	Mean Score (SD)		
Q26. How often do you use the concepts of EBM in your clinical practice?	4.09 (0.67)	3.54 (0.81)	**<0.0001**
Q27: How often do you read the following:			
Published RCTs	3.86 (0.63)	3.44 (0.67)	**0.00070**
Published EBGs	3.56 (0.62)	2.95 (0.74)	**<0.0001**
Textbooks	3.43 (0.76)	3.00 (1.12)	**0.029**
Published Meta-analyses	3.43 (0.54)	2.56 (0.78)	**<0.0001**
Information in Cochrane Library	3.02 (0.76) n=87	2.34 (0.88) n=41	**<0.0001**

EBM – Evidence Based Medicine; RCTs – Randomised Controlled Trials; EBGs – Evidence Based Guidelines; SD – standard deviation

Table 19. Appropriate users vs. non-users: Types of research used

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question number and response item)	Appropriate Users (N=88) Mean Score (SD)	Non-Users (N=41)	P-value
Q28. How often do you use the following information sources to guide decisions in your clinical practice?			
Published EBGs	3.75 (0.63)	3.24 (0.66)	**<0.0001**
Results of an RCT	3.73 (0.62)	3.15 (0.69)	**<0.0001**
Advice given by colleague	3.40 (0.67)	3.54 (0.84)	0.32
Textbook information	3.31 (0.73) n=88	3.06 (0.73) n=40	0.099
Conference presentations	3.18 (0.81)	3.10 (0.74)	0.57
Results of a Meta-analysis	3.42 (0.58)	2.10 (0.49)	**<0.0001**
Information from Google search	3.09 (0.92)	2.83 (0.95)	0.14
Evidence summary journals	2.92 (1.04) n=87	2.66 (0.91) n=41	0.17
Results of Cochrane review	3.03 (0.63)	2.29 (0.72)	**<0.0001**

EBGs – Evidence Based Guidelines; RCTs – Randomised Controlled Trials; SD – standard deviation

Table 20. Appropriate users vs. non-users: Situations where research is used

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item)	Appropriate Users (N=88)	Non-Users (N=41)	P-value
	Mean Score (SD)		
Q29: How often do you use published research evidence in the following situations			
Preparing a presentation for colleagues	3.84 (0.76) n=88	3.63 (0.81) n=40	0.15
Preparing a teaching session for trainees	3.85 (0.74)	3.53 (0.78)	**0.024**
Improving my knowledge	3.92 (0.59)	3.37 (0.66)	**<0.0001**
Developing guidelines or protocols	3.67 (0.85) n=88	3.38 (0.98) n=40	0.086
Making individual patient care decisions	3.73 (0.71) n=88	3.15 (0.81) n=39	**<0.0001**
Settling clinical dispute re patient management	3.43 (0.83) n=87	2.86 (0.72) n=40	**0.00040**
Reviewing management of a past patient (e.g. M&Ms)	3.32 (0.75) n=88	2.96 (0.58) n=40	**0.012**
Preparing to provide information to patient/ NOK	2.89 (0.78) n=88	2.50 (0.85) n=40	**0.013**

M&M – morbidity and mortality meetings; NOK – next of kin; SD – standard deviation

Table 21. Appropriate users vs. non-users: Factors that *help* the use of research to change practice

Allowable responses: *Never helps* (Score 1); *Rarely helps* (Score 2); *Sometimes helps* (Score 3); *Often helps* (Score 4); *Very often helps* (Score 5).

Variable (Question and response item)	Appropriate Users (N=88)	Non-Users (N=41)	P-value
	Mean Score (SD)		
Q30: How often are the following factors likely to help your decision to use results of published research evidence to change practice?			
The results have clear benefit to my patients	4.41 (0.54) n=88	4.28 (0.51) n=40	0.19
The project was methodologically sound, with no major flaws	4.32 (0.58) n=88	3.93 (0.47) n=40	**0.00030**
The intervention is described in enough detail so that I could implement it in my clinical practice	4.21 (0.70) n=87	4.00 (0.55) n=41	0.10
The paper fully explored all the possible benefits and harms	4.16 (0.59) n=88	3.88 (0.61) n=40	**0.013**
The project included a lot of patients	4.08 (0.63) n=88	3.82 (0.60) n=39	**0.032**
I understand the pathophysiological rationale of the intervention	4.00 (0.71) n=88	4.03 (0.77) n=40	0.86
The paper was clearly written (i.e. concise, coherent, to the point, logical)	4.10 (0.57) n=87	3.83 (0.45) n=40	**0.018**
The paper is the second publication on this topic to demonstrate a significant benefit to patients	3.97 (0.76) n=88	3.70 (0.72) n=40	0.066
The project involved multiple study centres	4.02 (0.71) n=88	3.43 (0.75) n=40	**<0.0001**
Other Intensivists have changed practice based on this paper	3.68 (0.84) n=88	3.55 (0.88) n=40	0.42
The project was conducted in my own health care system	3.55 (0.98) n=88	3.23 (1.03) n=40	0.094
The results will reduce costs but patient outcomes will not be compromised	3.36 (0.80) n=88	3.15 (0.92) n=40	0.19
The paper was written by a recognised expert in the field	3.30 (0.85) n=88	3.13 (0.94) n=40	0.31
The CONSORT or QUOROM statements were followed	3.31 (0.97) n=81	2.77 (1.15) n=31	**0.015**
I have seen the author present the findings of the project at a conference	3.10 (0.90) n=87	2.87 (0.95) n=39	0.19
The paper presents a full economic analysis	3.01 (0.94) n=88	2.43 (0.84) n=40	**0.00090**

CONSORT - Consolidated Standards of Reporting Trials; QUOROM - Quality of Reporting of Meta-analyses; SD – standard deviation

Table 22. Appropriate users vs. non-users: Factors that *inhibit* the use of research in clinical practice

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

Variable (Question and response item)	Appropriate Users (N=88)	Non-Users (N=41)	P-value
	Mean Score (SD)	Mean Score (SD)	
Q31: The following factors inhibit my use of published research evidence in clinical practice:			
I believe there is a lack of good evidence providing meaningful answers to my clinical problems.	3.49 (0.87) n=88	3.63 (0.93) n=40	0.42
Individual patient variation is not accounted for in the results of published research.	3.25 (0.97) n=88	3.69 (0.92) n=39	**0.018**
I have difficulty finding the time to read.	3.33 (0.97)	3.46 (0.98)	0.47
I can find papers using MEDLINE, but it is difficult to find key papers good enough to guide my practice.	2.99 (1.03)	3.37 (1.13)	**0.064**
I do not trust observational studies enough to use them to guide my practice.	2.92 (1.00) n=88	3.03 (0.97) n=40	0.58
I do not have enough training in EBM.	2.75 (1.02)	3.10 (1.04)	**0.076**
I have difficulties convincing my hospital to stock new drugs.	2.80 (1.03) n=88	2.73 (0.88) n=40	0.71
I have difficulties critically appraising papers.	2.60 (1.01)	2.88 (1.03)	0.15
I have insufficient authority to introduce some new practices into my hospital.	2.58 (0.99) n=88	2.88 (1.11) n=40	0.14
My colleagues do not support me when I am the first to change my own practice using new research evidence.	2.52 (0.84) n=88	2.60 (0.90) n=40	0.64
I have difficulties using MEDLINE.	2.25 (1.00)	2.63 (1.18)	**0.057**
Studies conducted in Europe and the USA do not apply to my patients.	2.24 (0.86)	2.49 (0.81)	0.12
Appraising published research papers is not part of my role.	1.94 (0.79)	2.55 (0.96)	**0.00030**

MEDLINE - U.S. National Library of Medicine® premier bibliographic database; EBM – Evidence Based Medicine; USA – United States of America; SD – standard deviation

Aim 3: To investigate whether identifiable clinician-level factors, characteristics of research studies, and factors that may inhibit research use are associated with the appropriate use of published research evidence in intensive care medicine.

To identify clinician-level factors and characteristics of research studies that were associated with the *appropriate use* of research evidence, multivariable logistic regression analysis was conducted. The primary outcome for this analysis was the binary variable *appropriate use* (yes/no).

Factors under study were identified for evaluation in multivariable regression if the univariable P-value was less than 0.10. Backwards stepwise elimination was used to develop a final model to identify all statistically significant independent predictors of appropriate use.

Univariable analysis

Clinician-level factors assessed for inclusion in the multivariable model included demographics (Table 23), research experience (Table 24) and research knowledge (Table 25). Characteristics of research evidence considered for inclusion in the final model are reported in Table 26. Factors that may inhibit the use of research evidence are reported in Table 27.

The following clinician-level factors were identified as candidates for evaluation in multivariable regression based on a univariable regression P-value less than 0.10: No formal training in EBM (OR 0.46, P=0.058), published as a named primary author (OR 2.49, P=0.036), experience running funded clinical trials (OR 3.86, P=0.00010), have consented a patient for a clinical trial (OR 3.27, P=0.040), CME hours per week (OR 1.10, P=0.086), mean knowledge score (OR 1.47, P=0.0022) and have used a computer for the purpose of a database search (OR 3.89, P=0.073).

The following characteristics of research studies were identified as candidates for evaluation in multivariable regression based on a univariable regression P-value less than 0.10: project conducted in own health care system (OR 1.38, P=0.096), project included a lot of

patients (OR 1.96, P=0.036), paper was clearly written (OR 2.41, P=0.021), paper fully explored all possible benefits and harms (OR 2.26, P=0.017), paper was methodologically sound, with no major flaws (OR 3.84, P=0.00080), study consistent with CONSORT or QUOROM statements (OR 1.64, P=0.018), project involved multiple study centres (OR 3.07, P<0.0001), paper is the second publication on this topic to demonstrate a significant benefit to patients (OR 1.59, P=0.071), paper presents a full economic analysis (OR 2.06, P=0.0016).

Factors that may inhibit research use that were identified as candidates for evaluation in multivariable regression based on a univariable regression P-value less than 0.10 included: difficulties using MEDLINE (OR 0.72, P=0.060), can find papers using MEDLINE, but difficulties finding key papers good enough to guide practice (OR 0.71; 0.066), belief that appraising published research papers is not part of job role (OR 0.46, P=0.00070), belief that they do not have enough training in EBM (OR 0.72, P=0.078), belief that individual patient variation is not accounted for in the results of published research (OR 0.61, P=0.021).

Multivariable analysis

All variables with a P-value less than 0.10 from the univariable analysis were included in a comprehensive multivariable model. After backwards stepwise elimination of non-significant variables, the following variables remained statistically significantly independently associated with appropriate use:

Mean knowledge score from six knowledge questions (OR 1.28, P=0.030),

Q8: Experience running funded clinical trials (OR 3.35, P=0.0081) and,

Q30(m): Project involved multiple study centres (OR 2.10, P=0.0017).

Complete details of the final model are reported in Table 28.

Table 23. Demographics: Univariable analysis of relationship with appropriate use

Variable*	Parameter Estimate	SE parameter estimate	Odds Ratio (95% CI)	P-value
Q1. Years practising	-0.0040	0.027	1.00 (0.94 to 1.05)	0.88
Q2. Gender (male referent)	0.013	0.25	1.03 (0.383 to 2.750)	0.96
Q3. Age in years	-0.022	0.022	0.98 (0.94 to 1.02)	0.31

SE – standard error; CI – confidence interval

Table 24. Research experience: Univariable analysis of relationship with appropriate use

Variable*	Parameter Estimate	Standard Error	Odds Ratio (95% CI)	P-value
Q4. Research training[*]				
Research Fellowship[*]	0.23	0.31	1.59 (0.47 to 5.34)	0.46
Research Course[*]	-0.41	0.40	0.44 (0.09 to 2.16)	0.31
Graduate Level Course[*]	0.72	0.50	2.06 (0.77 to 5.54)	0.15
None	0.095	0.21	1.21 (0.54 to 2.71)	0.65
Q5. EBM training[#]				
Non-university course[#]	0.22	0.20	0.65 (0.290 to 1.434)	0.28
University course[#]	-0.092	0.31	0.83 (0.25 to 2.83)	0.77
McMaster University[#]	0			
None	0.38	0.20	0.46 (0.21 to 1.02)	0.059
Q6. Academic appointment	0.011	0.19	1.02 (0.48 to 2.18)	0.96
Q7. Published author	-0.46	0.22	2.49 (1.06 to 5.85)	0.036
Q8. Run clinical trials	-0.67	0.21	3.86 (1.72 to 8.70)	<0.0001
Q9. Consented a patient	-0.59	0.29	3.27 (1.05 to 10.20)	0.040
Q10. Named on ethics submission	-0.071	0.20	0.87 (0.39 to 1.91)	0.73
Q11. Weekly CME hours	0.091	0.053	1.10 (0.99 to 1.21)	0.086
Q12. Internet use:	0.74	0.62	4.41 (0.39 to 0.10)	0.23
Q13. Computer use:[&]				
Word processing	-0.031	0.44	0.94 (0.17 to 5.35)	0.94
Data analysis	-0.25	0.19	0.61 (0.29 to 1.28)	0.19
Database search	-0.68	0.38	3.89 (0.88 to 17.20)	0.073
Other	0.35	0.27	2.01 (0.69 to 5.83)	0.20

CME- continuing medical education; CI – confidence interval

*respondents able to select more than one level of training or qualification in research

[#]respondents able to select more than one level of training or qualification in EBM

[&]respondents able to select more than one purpose for using a computer

Table 25. Research knowledge: Univariable analysis of relationship with appropriate use

Variable*	Parameter Estimate	SE parameter estimate	Odds Ratio 95% CI	P-value
Q14. CONSORT Statement	1.16	0.39	3.19 (1.48 to 6.88)	0.0031
Q15. Allocation concealment	0.39	0.43	1.47 (0.64 to 3.42)	0.37
Q16. PRISMA Statement	0.95	0.41	2.59 (1.17 to 5.72)	0.019
Q17. Statistical significance	2.24	1.14	9.41 (1.02 to 87.02)	0.048
Q18. I^2 metric	0.52	0.55	1.68 (0.57 to 4.91)	0.35
Q19. Forest plot	1.15	0.41	3.16 (1.41 to 7.12)	0.0054
Mean knowledge score	0.39	0.13	1.47 (1.15 to 1.89)	0.0022

CONSORT - Consolidated Standards of Reporting Trials; PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SE – standard error; CI – confidence interval

Table 26. Factors that help research change practice: Univariable analysis of relationship with appropriate use

Variable *	Parameter Estimate	SE parameter estimate	Odds Ratio 95% CI	P-value
Q30: Influential factors*				
Results have clear benefit	0.49	0.37	1.63 (0.79 to 3.35)	0.19
Methodologically sound, no major flaws	1.35	0.40	3.84 (1.75 to 8.44)	0.00080
Intervention described in detail for implementation	0.47	0.29	1.61 (0.90 to 2.85)	0.11
Explores benefits and harms	0.82	0.34	2.26 (1.16 to 4.41)	0.017
Includes a lot of patients	0.68	0.32	1.96 (1.05 to 3.68)	0.036
Pathophysiological rationale is understood	-0.048	0.26	0.95 (0.57 to 1.60)	0.86
Clearly written	0.88	0.38	2.41 (1.14 to 5.10)	0.021
Second publication to show benefit	0.46	0.267	1.59 (0.96 to 2.63)	0.071
Project involved multiple study centres	1.12	0.29	3.07 (1.73 to 5.47)	<0.0001
Other Intensivists have changed practice from results	0.19	0.23	1.20 (0.77 to 1.88)	0.42
Project was conducted own health care system	0.32	0.19	1.38 (0.95 to 2.00)	0.096
Results will reduce costs but not compromise patients	0.30	0.23	1.35 (0.87 to 2.11)	0.19
Paper written by expert	0.22	0.22	1.25 (0.81 to 1.92)	0.31
CONSORT or QUOROM followed	0.50	0.21	1.64 (1.09 to 2.48)	0.018
Seen author present results at a conference	0.28	0.22	1.33 (0.87 to 2.02)	0.19
Paper presents economic analysis	0.72	0.23	2.06 (1.32 to 3.23)	0.0016

CONSORT - Consolidated Standards of Reporting Trials; QUOROM - Quality of Reporting of Meta-analyses; SE – standard error; CI – confidence interval

Summary of question and identifiers only, for complete wording of questions and influential factors, see Appendix C.

Table 27. Factors that inhibit research use: Univariable analysis of relationship with appropriate use

Variable*	Parameter Estimate	SE parameter estimate	Odds Ratio 95% CI	P-value
Q31: Inhibiting factors*				
Lack of good evidence	-0.18	0.22	0.84 (0.54 to 1.29)	0.42
Individual patient variation is not accounted for in results	-0.50	0.22	0.61 (0.40 to 0.93)	0.021
Difficulty finding the time to read	-0.15	0.20	0.86 (0.58 to 1.28)	0.46
Difficult to find key papers that are good enough	-0.34	0.18	0.71 (0.50 to 1.02)	0.066
Do not trust observational studies to guide practice	-0.11	0.20	0.90 (0.61 to 1.31)	0.58
Do not have enough training in EBM	-0.33	0.19	0.72 (0.50 to 1.04)	0.078
Difficulties convincing my hospital to stock new drugs	0.074	0.20	1.08 (0.73 to 1.58)	0.71
Difficulties critically appraising papers	-0.27	0.19	0.76 (0.53 to 1.11)	0.15
Insufficient authority to introduce new practices	-0.28	0.19	0.76 (0.53 to 1.09)	0.14
Colleagues do not support me if the first to change practice	-0.11	0.22	0.90 (0.58 to 1.39)	0.64
Difficulties using MEDLINE.	-0.33	0.18	0.72 (0.51 to 1.01)	0.060
Studies conducted in Europe and USA do not apply	-0.34	0.22	0.71 (0.46 to 1.10)	0.12
Appraising published research not part of my role	-0.79	0.23	0.46 (0.29 to 0.72)	0.00070

MEDLINE - U.S. National Library of Medicine[®] premier bibliographic database; EBM – Evidence Based Medicine; SE – standard error; CI – confidence interval

Summary of question and identifiers only, for complete wording of questions and inhibiting factors, see Appendix C.

Table 28. Final multivariable model: Factors independtly associated with appropriate use.

Variable	Parameter Estimate	SE parameter estimate	Odds Ratio 95% CI	P-value
Mean knowledge score	0.310	0.14	1.28 (0.963 to 1.701)	0.030
Q8. Involved in running funded clinical trials.	1.21	0.46	3.35 (1.369 to 8.214	0.0081
Q30m. Multicentred clinical trial	0.74	0.33	2.10 (1.101 to 3.994)	0.024

SE – standard error; CI – confidence interval; Knowledge score: Total score correct out of six; Q8: Is involved in the running of any funded clinical trials; Q30(m): The project involved multiple study centres

Aim 4: To design an intervention or tool to improve the use of published research evidence in clinical decision making.

Evidence summary tool development and design

Literature search

Key publications that reported clinicians' attitudes towards research evidence, characteristics of published research evidence that help change practice, preferences for types of research evidence, or factors inhibit the use of research evidence.[34-36, 39-45, 51, 68, 94, 104]

Additional key published studies were identified that summarised the literature related to barriers encountered by clinicians when using evidence summary resources.[58, 91]

Mapping exercise

Ely *et al.* identified 59 factors commonly encountered by clinicians that inhibit the use of research evidence when attempting to answer clinical questions.[91] Perrier *et al.* identified 25 barriers to research transfer in their review of the field.[58] Additionally, Heighes and Doig investigated the importance of 11 factors that inhibit the use of research evidence amongst intensive care clinicians.[104] The complete list of barriers and inhibitory factors was reviewed by two investigators (PTH and GSD) and 27 barriers were deemed relevant and addressable in the design of the evidence summary tool. The complete list of barriers is reported in Table 29.

During the mapping exercise, a specific design element was proposed to ensure each barrier was addressed within the evidence summary tool design. For example, for the barrier *resource poorly organised* the design element to address this barrier was *tool structured and designed with clear sections to organise content*. For the barrier *resource not current* the design element to address this barrier was *date of production of evidence summary tool included in footer on document*. Table 29 reports the complete results of the mapping exercise.

Table 29. Barriers encountered by clinicians when using research evidence and design elements included in the evidence summary tool to address each barrier

1. Topic or relevant aspect of topic not included in a resource that should include it Based on the title of the article or book, coverage of the topic would have been expected. **Design element:** Patient group, intervention and outcome all included in title to ensure the topic of tool is clearly identifiable.
2. Resource poorly organised Resources may be poorly organised within a personal library or reprint file. Information within a resource may be poorly organised or have inadequate titles or subtitles. **Design element:** Tool structured and designed with clearly separated sections to organise content.
3. Resource not clinically oriented For example, textbooks may be organised by organ system rather than by disease, which forces the doctor to "work backwards." **Design element:** Title of evidence summary tool clearly identified clinical topic and use of a clinical intervention.
4. Resource not authoritative or not trusted The resource may not be authoritative or it may not be trusted by the searcher. **Design element:** Research unit name, contact details and professional logo included in document to demonstrate legitimacy of authors. Full references of publications summarised in tool included in document.
5. Resource not current The resource may not be current or it may be difficult to know if it is current (for example, undated internet sites and printed material). **Design element:** Date of production of evidence summary tool included in footer on document.
6. Incorrect information The information simply may be wrong. **Design element:** Clinical content review conducted to ensure transfer of information from primary sources was correct. Primary sources of evidence published in high quality peer-reviewed journals.
7. Information not current The resource containing the information may be current, but the information itself is not current. **Design element:** Primary evidence sources published within last 3 years. Dates of publication included in the full citation listed on tool.
8. Failure to anticipate ancillary information needs There is inadequate anticipation of likely ancillary or follow up questions (for example, the name of a recommended drug is provided but not the dose, forcing the searcher to consult another resource). **Design element:** Links to educational resources to enable successful implementation of intervention provided.
9. Failure to define important terms The information includes terms that are not defined. For example, treatment may vary depending on whether the disease is mild, moderate, or severe, but these terms are not defined. **Design element:** All important clinical terms defined within document.
10. Inadequate description of clinical procedures A clinical procedure (for example, thoracentesis) is described but there is insufficient detail to allow the doctor to do it. **Design element:** Guide for implementation of intervention in clinical practice included.
11. Vague or tangential information The information does not allow the question to be answered directly because of a vague, tangential, or overly general format. **Design element:** Clear, succinct and firm summary of important information.
12. Unnecessarily cautious writing style The information is overly cautious and may contain unnecessary hedge words ("can," "may," etc). The caution may be legitimate (inadequate evidence to support a definitive statement), but it may be unnecessary **Design element:** Writing style is direct and logical with an active voice used to convey benefit to patients.
13. Tertiary care approach to primary care problem Available information may take an urban interventionist tertiary care approach, which may not be useful to a rural primary care doctor with a non-interventionist philosophy. **Design element:** The intervention examined specifically relates to the treatment of the medical problem.
14. Biased information due to conflicts of interest The author or editor may have conflicts of interest. **Design element:** No affiliations with industry that would influence findings or presentation of tool.
15. Failure to address the clinical question

Available studies have not adequately addressed the question (for example, "Is smoking a risk factor for sinusitis?"). **Design element:** A specific and focused clinical question is addressed.
16. *Failure to study the comparison of interest* Drug companies often sponsor clinical trials comparing drug A with placebo, but the question is whether drug A is better than drug B. **Design element:** A comparison of interest is addressed.
17. *Failure to study the outcome of interest* An intermediate outcome, such as serum cholesterol level, may be studied rather than more clinically Yes outcomes, such as myocardial infarction or death. **Design element:** A clear primary outcome is addressed.
18. *Failure to study the population of interest* It may not be appropriate to apply results from a referral population to the primary care setting. **Design element:** A patient population of interest is clearly identified.
19. *Evidence based on flawed methods* Multiple flaws (for example, selection bias, misclassification bias, confounding, etc) may invalidate the results. **Design element:** Primary evidence sources obtained from high quality peer-reviewed journals. Quality assessment of primary evidence sources conducted and reported within tool.
20. *Failure to cite or include relevant evidence* Evidence exists but is not cited. It may be difficult to know if evidence exists and, if it exists, to what extent it has been used to write a chapter or review. **Design element:** Full reference citations of primary evidence sources provided with links in electronic version that take reader directly to abstract in PubMed.
21. *Inadequate synthesis of multiple bits of information* Relevant evidence is available but consists of numerous bits of information that have not been randomized or interpreted. Evidence may be randomized but not systematically or rigorously. Conflicting evidence is presented without providing a definitive recommendation for the clinician who must make a decision. **Design element:** Information synthesised to provide clinical bottom line and numbers of patients saved with intervention.
22. *Difficulty applying results of randomised clinical trials to individual patients* Clinical trials are often narrow in scope and may not apply to patients with comorbid conditions. **Design element:** Clear identification of patient population that can benefit from intervention with one tool based primarily on RCT results.
23. *Failure to directly or completely answer the question* Once the relevant information has been gathered, the searcher fails to directly or completely answer the doctor's question (for example, owing to the inadequacy of available information or an inadequate synthesis of adequate information). **Design element:** Primary outcome addressed along with clinically important benefits and harms thus providing a comprehensive answer to the clinical usefulness of the intervention.
24. *Answer directed at the wrong audience* Answers for patients may not be helpful to doctors. **Design element:** The target audience is established with writing of the document directed towards this group.
25. *Difficulty addressing unrecognised information needs apparent in the question* It may not be clear how to address unrecognised information needs that are evident in the question. For example, the question might ask about the dose of a drug that is contraindicated ("What is the dose of tetracycline for acne in a pregnant woman?"). **Design element:** Potential harms arising from the intervention and rates of occurrence are outlined in the tool.
26. *Answer not trusted* A seemingly adequate answer may not be used if the doctor does not trust the source. **Design element:** Primary evidence sources obtained from high quality peer-reviewed journals. Full reference citations of primary evidence sources provided with links in electronic version that take reader directly to abstract in PubMed.
27. *Answer inadequate* If the answer is thought to be inadequate by the doctor, it may not be used to direct patient care. **Design element:** The physiological rationale for HOW the intervention works and steps for implementing the intervention in clinical practice are provided along with references to additional educational resources.

Selection of a clinical intervention to be presented in the evidence summary tool

Univariable analysis conducted to identify characteristics of research evidence that were associated with *appropriate use* (Aim 3) indicated the following characteristics of published research papers were significantly associated with *increased* appropriate use: sound methods with no major flaws (OR 3.84, P=0.00080), multicentred study (OR 3.07, P=0.00010), clear concise writing style (OR 2.41, P=0.021), fully explored all possible benefits and harms (OR 2.26, P=0.017), reported an economic analysis (OR 2.06, P=0.0016), larger study size (OR 1.96, P=0.036),with reporting and conduct consistent with the CONSORT statement (OR 1.64, P=0.018).

Results of the multivariable analysis conducted to identify characteristics of research evidence that were *independently* associated with appropriate use (Aim 3) indicated clinicians may be more likely to use evidence from *multicentre studies* (OR 2.10, P=0.024). No other characteristics of research evidence remained statistically significant in the final multivariable model.

The use of prone positioning in patients with severe acute respiratory distress was identified as an area of practice in intensive care medicine for which the supporting evidence fulfils the criteria described above and for which a proven evidence-practice gaps exist.[5, 6, 32, 33]

Pilot testing

The feedback from pilot testing and clinical content review of the evidence summary tool highlighted that the section titled 'implementing prone positioning in suitable patients' was unclear, and that it was difficult to differentiate the beginning of each step in the implementation process. Identification numbers were added to each step in the implementation process to improve clarity. Suggestions for minor changes to wording and grammar were also made by pilot testers to improve readability. The final evidence summary tool is shown in Figure 6 (over page).

Figure 6. Evidence summary tool

Early Prone Positioning Saves Lives in Severe Acute Respiratory Distress Syndrome

Philippa Heighes, Research Fellow (email: pheighes@med.usyd.edu.au)
Northern Clinical School Intensive Care Research Unit, University of Sydney Australia

Prone Positioning in ARDS saves lives

To save 1 life you need to prone 6 patients with severe ARDS on low-tidal volume ventilation.

This is supported by a significant mortality reduction in a well conducted RCT analysing 466 patients from 27-hospitals and 5 smaller RCTs enrolling an additional 542 patients.

Other patient benefits

For every 15 patients proned, 1 cardiac arrest is prevented.[1]

For every 7 patients proned, 1 additional patient is successfully extubated before Day 90. [1]

Potential harms

For every 25 patients proned, 1 transient endotracheal tube obstruction occurs.[2]

For every 77 patients proned, 1 thoracotomy tube is dislodged.[2]

For every 10 patients proned, 1 additional pressure ulcer occurs.[2]

There is no documented increase in additional accidental extubations.[1,2,3]

Identifying patients that will benefit from prone positioning

1) Identify *severe ARDS* patients *early*
   Intubated and ventilated < 36 hours AND $PaO_2:FiO_2$ ratio < 150mmHg.
2) Implement *low-tidal volume* ventilation for a period of 12 to 24 hours
   Ensure PEEP is at least $5cmH_2O$ and $FiO_2 \geq 0.6$.
3) If PaO2:FiO2 ratio remains < 150 mmHg, consider proning.

Implementing prone positioning in suitable patients

1) Maintain prone position for *at least* 16 consecutive hours.
2) Following return to supine position reassess $PaO_2:FiO_2$ ratio and continue to use prone positioning each day if $PaO_2:FiO_2$ ratio < 150mmHg.
3) If $PaO_2:FiO_2$ ratio $\geq$ 150mmHg and PEEP $\leq$ $10cmH_2O$ and $FiO_2 \leq 0.6$ cease prone positioning.

Useful educational resources regarding prone positioning

The successful management of the patient in prone position relies on the skill of the staff performing the procedure. Adequate training and experience of staff is key to maintaining patient safety and minimising potential harms.

Guidelines for standardising prone positioning and a useful 5 minute training video demonstrating prone positioning procedure available at http://www.nejm.org/

A complete list of eligibility criteria and contraindications can be found at http://www.nejm.org/suppl

Physiological rationale of why prone position is beneficial

Prone positioning leads to more equal ventilation perfusion match; more uniform alveolar recruitment and expansion; and more even distribution of pleural pressure within the lungs

Brief summary of Evidence Reviewed

466 patient RCT[1] published in NEJM in 2013. There were no major flaws in this paper.

Five additional RCTs enrolled 22 - 344 patients each. Four of these additional RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation.[2,3]

References – click journal title for PubMed link

1. Guerin C et al. *Prone positioning in severe acute respiratory distress syndrome.* **NEJM** 2013;368:2159-68.
2. Sud S et al. *Effect of prone positioning during mechanical ventilation on mortality among patients with acute respiratory distress syndrome: a systematic review and meta-analysis.* **CMAJ** 2014; 186:E381-E390.
3. Beitler J et al. *Prone positioning reduces mortality from acute respiratory distress syndrome in the low tidal volume era: a meta analysis.* **ICM** 2014; 40:332-341.

Aim 5: To understand and describe attitudes towards and patterns of use of published research evidence in clinical decision making amongst a multinational mixed group of intensive care clinicians.

Quantitative e-mail questionnaire survey design

The questionnaire included a total of 26 closed ended questions divided into three main sections.

The first section titled *Demographics and Research Experience* addressed items related to year of registration as an intensive care specialist, gender, age, experience and participation in research activities, continuing medical education time, formal research qualifications and training in evidence-based medicine.

The second section titled *Research attitudes* included statements related to beliefs and attitudes regarding published research evidence, with respondents asked to select the most appropriate answer from a balanced five point Likert item response scale (strongly disagree, disagree, neutral, agree, strongly agree).

The third section titled *Research use* collected details of patterns of research use in clinical practice.

Based on the items collected above, the metric *appropriate use* was calculated as per the methods of De Vito *et al.*[45]

The complete questionnaire can be viewed in Appendix E.

Pilot testing

The two pilot testers identified that large response boxes for some questions made it difficult to determine which question they applied to. To improve readability, the size of response boxes was adjusted and spacing between questions was increased.

The use of small font in the footer of the questionnaire document was identified by the pilot testers as difficult to read, to improve readability all font size was set to a minimum of 12 points.

Response rate

The sample for this study included 1,000 members of the Critical Care Medicine e-mail List (CCM-L), an e-mail discussion forum run out of the University of Pittsburgh. The first recruitment e-mail was sent to all members on the 25th August 2015, with monthly recruitment e-mails sent out for a period of one year until August 2016. In response to these recruitment e-mails, 122 members agreed to participate in the survey.

All 122 volunteer participants were sent questionnaires by e-mail. In order to maximise response rates, follow up e-mails were sent to all participants who received questionnaires at least twice (January 2016 and August 2016). The final questionnaire was received in August 2016 following which the survey was closed out.

Ninety-three participants returned questionnaires, resulting in an overall response rate of 9.3% (93/1,000).

Missing items

Six of the 93 questionnaires were returned completely blank. Overall incomplete data at the question item level was 9.7% (341 missing values from 93 returned surveys with 38 question items on each survey). Missing values for individual questions ranged from 6.5% (87/93) missing to 25.8% (69/93) missing.

Full details of item response rates by individual question are reported in Table 30,Table 31,Table 32,Table 33,Table 34 and Table 35.

Responses

Demographics

      The mean age of respondents was 49.59 (9.33) years with males making up 87.3% (62/71) of the responding population. Respondents reported a mean of 20.03 (9.87) years of clinical experience working in the field of intensive care medicine. Fifty percent (43/86) of respondents worked as a full time intensive care specialist and 25.6% (22/86) worked as a part time intensive care specialist. Nurses (6/86), pharmacists (2/86) and respiratory therapists (2/86) also participated in this study.

      The largest number of respondents reported their primary country of residence as the United States (15/70), followed by Australia (11/70). Primary country of residence of respondents is shown by country in Figure 7 (next page).

      Complete details of demographics of all respondents can be seen in Table 30.

Research experience

      Forty percent (30/71) of respondents reported that they held an academic appointment at a university. The weekly mean time devoted to continuing medical education was 6.19 (SD 3.99) hours per week. Formal research training was reported by 44.8% (39/87) of respondents, whilst 47.1% (41/87) reported they had completed formal training in evidence-based medicine.

      Full details regarding research experience can be found in Table 31.

Research attitudes

      Ninety-three percent (82/87) of respondents reported positive feelings (*agreed* or *strongly agreed*) towards using the results of an RCT to guide their clinical practice, whereas 83.7% (72/86) of respondents reported positive feelings towards using the results of a systematic review to guide their clinical practice (*agreed* or *strongly agreed*).

Figure 7 Primary country of residence

- ☐ Australia (n=11)
- ☐ Brazil (n=1)
- ☐ Canada (n=5)
- ☐ Germany (n=4)
- ☐ Greece (n=2)
- ☐ India (n=4)
- ☐ Italy (n=3)
- ☐ Japan (n=1)
- ☐ Netherlands (n=2)
- ☐ New Zealand (n=3)
- ☐ Pakistan (n=1)
- ☐ Portugal (n=4)
- ☐ Saudi Arabia (n=2)
- ☐ Slovakia (n=3)
- ☐ South Africa (n=1)
- ☐ Spain (n=2)
- ☐ Sweden (n=2)
- ☐ United Kingdom (n=4)
- ☐ United States (n=15)
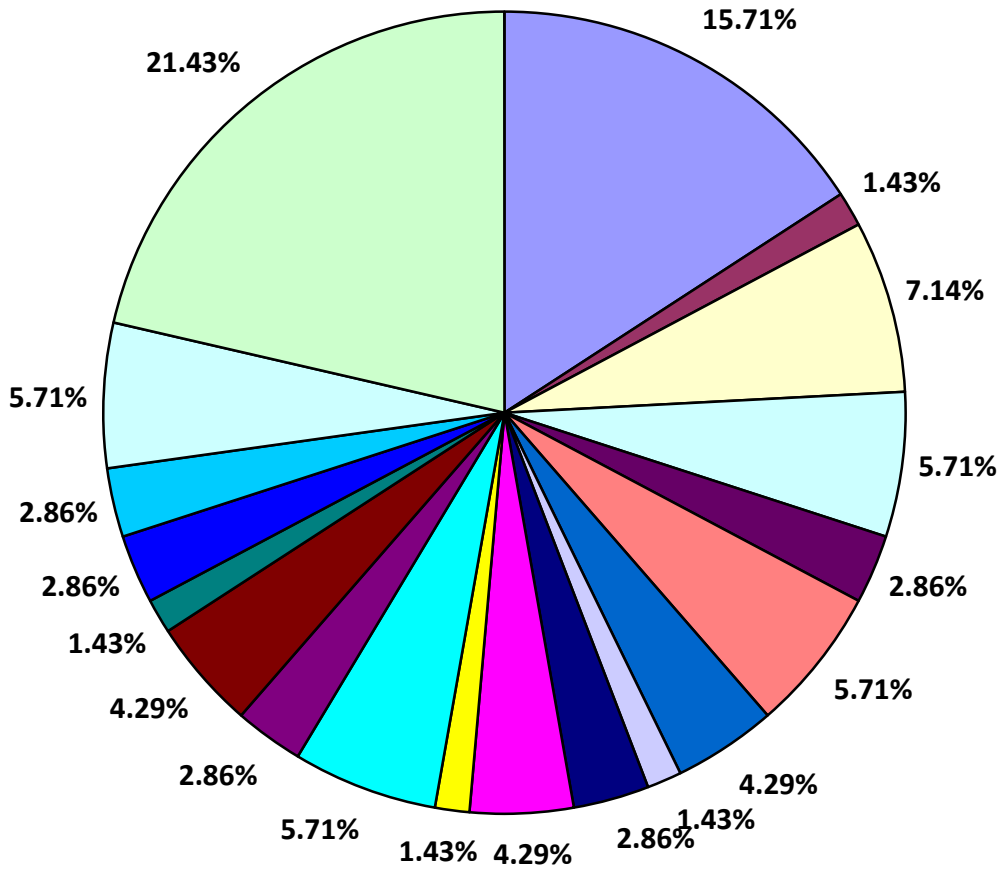
Research use

Ninety-nine percent (84/85) of respondents reported they used the concepts of evidence-based medicine in their own clinical practice *at least sometimes,* which was defined as 'every month or so'.

With regards to the *frequency of reading* different types of research evidence, 95.4% (83/87) of respondents reporting they read RCTs *at least sometimes* whereas 72.4% (63/87) of

respondents reported they read *information in the Cochrane library at least sometimes*.
Complete details regarding frequency of reading specific types of research evidence are
reported in Table 33.

In a question regarding *frequency of using* different types of research evidence *to guide clinical practice*, Published Evidence Based Guidelines were used by 96.65% (84/87) of respondents *at least sometimes* whereas 78.2% (68/87) of respondents reported using *information in the Cochrane Library* to guide clinical decisions *at least sometimes*. Complete details regarding patterns of use of research evidence are reported in Table 34.

Appropriate use

Responses were reviewed for each respondent to the four key questions within the questionnaire designed to measure appropriate use according to the metric of De Vito *et al.*[45]

A total of 87 respondents (N=87) provided complete responses to all four key questions and were eligible for calculation of the *appropriate use* metric. From these 87 respondents, 73 reported they read RCTs *at least sometimes* **and** read systematic reviews *at least sometimes* **and** used RCTs *at least sometimes* **and** used systematic reviews *at least sometimes*.

Thus, the overall *appropriate use* rate was 73/87 (83.9%, 95% CI 76.2 to 90.9). Table 35 shows complete responses for each of the four key questions used to score appropriate use.

Table 30. Demographics

Variable	Response Rate $(n/N)^{\&}$	Result
Q1. Gender - male, percent (n/N)	71/93	87.3% (62/71)
Q2. Age in years, mean (SD)	69/93	49.59 (9.33)
Q4. Years working in ICU, mean (SD)	70/93	20.03 (9.87)
Q5. Academic appointment (university), percent (n/N)	70/93	40.3% (30/71)
Q6. Weekly CME hours, mean (SD)	70/93	6.19 (3.99)
Q7. Current primary work role:	86/93	
Part time ICU, primary specialty other field		25.6% (22/86)
Full time ICU specialist		50.0% (43/86)
ICU trainee		2.3% (2/86)
Nurse		7.00% (6/86)
Dietitian		0
Physiotherapist		0
Occupational therapist		0
Respiratory therapist		2.3% (2/86)
Pharmacist		2.3% (2/86)
Other		10.5% (9/86)

n/N - number of reported events/Number of responses; SD - standard deviation; ICU - Intensive Care Unit; CME - Continuing Medical Education; $n/N^{\&}$ item response rate/unit response rate

Table 31. Research experience

Variable	Response rate $(n/N)^{\&}$	Result percent (n/N)
Q8. Level of training or qualification in research[*]	87/93	
Research Fellowship[*]		13.8% (12/87)
Formal Research Methodology Course[*]		18.4% (19/87)
Graduate Level Research Methodology Course[*]		
Graduate Certificate		3.5% (3/87)
Graduate Diploma		3.5% (3/87)
Masters		9.2% (8/87)
PhD		5.8% (5/87)
No formal research qualification		55.2% (48/87)
Q9. Level of training or qualification in EBM[#]	87/93	
Have attended a non-university based EBM course or workshop[#]		35.6% (31/87)
Have attended a McMaster University course or workshop[#]		0
Have attended a University based EBM course or workshop[#]		12.6% (11/87)
No formal EBM training		52.9% (46/87)

PhD – Doctor of Philosophy; EBM – Evidence Based Medicine; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses

respondents able to select more than one level of training or qualification in research

[#]*respondents able to select more than one level of training or qualification in EBM*

Table 32. Research attitudes

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

Variable (Question number)	Response Rate $(n/N)^{\&}$	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q25. My feeling towards using the results of an RCT to guide my clinical practice are positive	87/93	0 (0/87)	1.2 (1/87)	5.8 (5/87)	54.0 (47/87)	39.1 (34/87)	4.31 (0.63)
Q26. My feelings towards using the results of a systematic review/meta-analysis to guide my clinical practice are positive	86/93	0 (0/86)	2.3 (2/86)	14.0 (12/86)	50.0 (43/86)	33.7 (29/86)	4.15 (0.74)

RCT – randomised controlled trial; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 33. Frequency of research use

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item)	Response Rate $(n/N)^{\&}$	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q10. How often do you use the concepts of EBM in your clinical practice?	85/93	1.2 (1/85)	0 (0/85)	16.5 (14/85)	42.4 (36/85)	40.0 (34/85)	4.20 (0.80)
Q11: How often do you read the following: (Listed in order from most highly ranked)							
Published RCTs	87/93	0 (0/87)	4.6 (4/87)	12.6 (11/87)	57.5 (50/87)	25.3 (22/87)	4.03 (0.75)
Published EBGs	87/93	0 (0/87)	5.8 (5/87)	33.3 (29/87)	36.8 (32/87)	24.1 (21/87)	3.79 (0.88)
Published systematic reviews/meta-analyses	87/93	0 (0/87)	5.8 (3/87)	36.8 (32/87)	43.7 (38/87)	16.1 (14/87)	3.72 (0.77)
Evidence summaries	87/93	2.3 (2/87)	6.9 (6/87)	40.2 (35/87)	33.3 (29/87)	17.2 (15/87)	3.56 (0.94)
Information in Cochrane Library	87/93	1.2 (1/87)	26.4 (23/87)	42.5 (37/87)	25.3 (22/87)	4.6 (4/87)	3.06 (0.87)
Textbooks	83/93	6.0 (5/83)	39.8 (33/83)	24.1 (20/83)	21.7 (18/83)	8.4 (7/83)	2.87 (1.09)

EBM – Evidence Based Medicine; RCTs – Randomised Controlled Trials; EBGs – Evidence Based Guidelines; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 34. Types of research used

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Variable (Question and response item) Listed in order from most highly ranked	Response Rate $(n/N)^{\&}$	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	2	3	4	5	
Q12: How often do you use the following information sources to guide decisions in your clinical practice?							
Published EBGs	87/93	0 (0/87)	5.8 (3/87)	20.7 (18/87)	44.8 (39/87)	31.0 (27/87)	4.03 (0.81)
Results of an RCT	87/93	0 (0/87)	4.6 (4/87)	18.4 (16/87)	50.6 (44/87)	26.4 (23/87)	3.99 (0.80)
Results of a systematic review/meta-analysis	87/93	1.2 (1/87)	12.6 (11/87)	25.3 (22/87)	39.1 (34/87)	21.8 (19/87)	3.68 (0.99)
Results of Cochrane review	87/93	2.3 (2/87)	19.5 (17/87)	37.9 (33/87)	33.3 (29/87)	6.9 (6/87)	3.23 (0.92)
Advice given by colleague	87/93	4.6 (4/87)	10.3 (9/87)	51.7 (45/87)	27.6 (24/87)	5.8 (5/87)	3.20 (0.87)
Textbook information	87/93	2.3 (2/87)	26.4 (23/87)	32.2 (28/87)	29.9 (26/87)	9.2 (8/87)	3.17 (1.00)
Evidence summary journals	87/93	4.6 (4/87)	25.3 (22/87)	31.0 (27/87)	28.7 (25/87)	10.3 (9/87)	3.15 (1.06)
Information from Google search	87/93	4.6 (4/87)	23.0 (20/87)	40.2 (35/87)	20.7 (18/87)	11.5 (10/87)	3.12 (1.04)

EBGs – Evidence Based Guidelines; RCTs – Randomised Controlled Trials; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 35. Individual responses to key questions used to score appropriate use

Allowable responses: *Never* (1); *Rarely* = once or twice a year (2); *Sometimes* = every month or so (3); *Often* = every week or so (4); *Very often* = every day or so (5).

Variable (Question and response item) Listed in order from most highly ranked	Response Rate $(n/N)^{\&}$	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	**2**	**3***	**4***	**5***	
Q11: How often do you read the following:							
a: Published RCTs	87/93	0 (0/87)	4.6 (4/87)	**12.6 (11/87)**	**57.5 (50/87)**	**25.3 (22/87)**	4.03 (0.75)
e: Published Meta-analyses	87/93	0 (0/87)	5.8 (3/87)	**36.8 (32/87)**	**43.7 (38/87)**	**16.1 (14/87)**	3.72 (0.77)
Q12. How often do you use the following information sources to guide decisions in your clinical practice?							
e: Results of an RCT	87/93	0 (0/87)	4.6 (4/87)	**18.4 (16/87)**	**50.6 (44/87)**	**26.4 (23/87)**	3.99 (0.80)
h: Results of a Meta-analysis	87/93	1.15 (1/87)	12.6 (11/87)	**25.3 (22/87)**	**39.1 (34/87)**	**21.8 (19/87)**	3.68 (0.99)

RCTs – randomised controlled trials; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

A response of sometimes (3), often (4) or very often (5) was allocated a score of 1 on the appropriate use metric

Aim 6: To conduct an intervention to determine whether an evidence summary tool can improve the use of published research evidence to support clinical decision making.

Online interventional study

Case-based scenario

A clinical case-based scenario was developed that outlined a typical ICU patient presenting with a clinical condition that would benefit from treatment with the intervention 'prone positioning' as summarised in the evidence summary tool.

"Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status."

Belief in the benefit of specific clinical interventions

Before reading the evidence summary tool

Before reading the evidence summary tool, 88.5% (77/87) of respondents reported they agreed with the statement that the patient in the clinical scenario would benefit from prone positioning (*agree* or *strongly agree*).

With regards to the five other listed clinical interventions, agreement (*agree* or *strongly agree*) that the patient in the clinical scenario would benefit from High Frequency Oscillatory Ventilation was 16.1% (14/87), for Non-Invasive BiPAP agreement was 2.3% (2/86), for Corticosteroids agreement was 20.7% (18/87), for increased levels of PEEP agreement was

56.3% (49/87), and for ECMO agreement was 52.9% (46/87). Table 36 provides complete responses to these question items.

After reading the evidence summary tool

After reading the evidence summary tool, 93.1% (81/87) of respondents reported they agreed the patient in the clinical scenario would benefit from prone positioning (*agree* or *strongly agree*).

With regards to the five other listed clinical interventions, agreement (*agree* or *strongly agree*) that the patient in the clinical scenario would benefit from High Frequency Oscillatory Ventilation was 17.2% (15/87), for Non-Invasive BiPAP agreement was 2.3% (2/86), for Corticosteroids agreement was 18.6% (16/86), for increased levels of PEEP agreement was 51.7% (45/87), and for ECMO agreement was 49.4% (43/87). Table 37 provides complete responses to these question items.

Change in strength of belief of benefit from before to after

Comparing *strength* of agreement before reading the evidence summary tool to *strength* of agreement after reading the evidence summary tool, there was a significant increase in the strength of agreement with the statement that the patient in the clinical scenario would benefit from prone positioning (mean score change 0.32, 95% CI 0.19 to 0.46, P<0.001).

There was also a significant *reduction* in strength of agreement with the statement that the patient in the clinical scenario would benefit from increased levels of PEEP (mean score change -0.15, 95% CI -0.24 to -0.06, P=0.0020) and a trend towards a *reduction* in the strength of agreement the statement the patient in the clinical scenario would benefit from ECMO (mean score change -0.13, 95% CI -0.26 to 0.01, P=0.070). Table 38 provides complete responses to these question items.

Table 36. Belief in the benefit of specific clinical interventions, before reading evidence summary tool

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

Variable (Intervention)	Response Rate (n/N)$^{\&}$	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	**2**	**3**	**4**	**5**	
Q13. I believe that this patient may benefit from High Frequency Oscillatory Ventilation.	87/93	16.1 (14/87)	36.8 (32/87)	31.0 (27/87)	14.9 (13/87)	1.2 (1/87)	2.48 (0.97)
Q14. I believe that this patient may benefit from Prone Positioning.	87/93	1.2 (1/87)	4.6 (4/87)	5.8 (5/87)	48.3 (42/87)	40.2 (35/87)	4.22 (0.84)
Q15. I believe that this patient may benefit from Non-Invasive BiPAP ventilation	86/93	64.0 (55/86)	25.6 (22/86)	8.1 (7/86)	2.3 (2/86)	0 (0/86)	1.49 (0.75)
Q16. I believe that this patient may benefit from the use of Corticosteroids	87/93	17.2 (15/87)	32.2 (28/87)	29.9 (26/87)	17.2 (15/87)	5.8 (3/87)	2.58 (1.07)
Q17. I believe that this patient may benefit from the use of increased levels of PEEP	87/93	1.2 (1/87)	16.1 (14/87)	26.4 (23/87)	41.4 (36/87)	14.9 (13/87)	3.53 (0.98)
Q18. I believe that this patient may benefit from ECMO	87/93	1.2 (1/87)	11.5 (10/87)	34.5 (30/87)	44.8 (39/87)	8.1 (7/87)	3.47 (0.85)

BiPAP - Bi-Level Positive Airway Pressure; PEEP - Positive End Expiratory Pressure; ECMO – Extra-Corporeal Membrane Oxygenation; $n/N^{\&}$ item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 37. Belief in the benefit of specific clinical interventions, after reading evidence summary tool

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

Variable (Intervention)	Response Rate (n/N)[&]	Respondents selecting each category Percent (n/N)					Mean score (SD)
		1	2	3	4	5	
Q19. I believe that this patient may benefit from High Frequency Oscillatory Ventilation.	87/93	20.7 (18/87)	37.9 (33/87)	24.1 (21/87)	12.6 (11/87)	4.6 (4/87)	2.43 (1.10)
Q20. I believe that this patient may benefit from Prone Positioning.	87/93	0 (0/87)	0 (0/87)	6.9 (6/87)	32.2 (28/87)	60.9 (53/87)	4.54 (0.63)
Q21. I believe that this patient may benefit from Non-Invasive BiPAP ventilation	86/93	61.6 (53/86)	24.4 (21/86)	8.2 (7/86)	2.3 (2/86)	0 (0/86)	1.48 (0.75)
Q22. I believe that this patient may benefit from the use of Corticosteroids	86/93	19.8 (17/86)	29.1 (25/86)	32.6 (28/86)	16.3 (14/86)	2.3 (2/86)	2.52 (1.06)
Q23. I believe that this patient may benefit from the use of increased levels of PEEP	87/93	5.8 (3/87)	21.8 (19/87)	23.0 (20/87)	36.8 (32/87)	14.9 (13/87)	3.38 (1.09)
Q24. I believe that this patient may benefit from ECMO	87/93	5.8 (3/87)	13.8 (12/87)	33.3 (29/87)	43.7 (38/87)	5.8 (5/87)	3.35 (0.91)

BiPAP - Bi-Level Positive Airway Pressure; PEEP - Positive End Expiratory Pressure; ECMO – Extra-Corporeal Membrane Oxygenation; *n/N*[&] item response rate/unit response rate; n/N – number of reported events/Number of responses; SD – standard deviation

Table 38. Change in belief in the benefit of specific clinical interventions from before to after reading evidence summary tool

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

	Mean Score (SD)		Mean change in score (SD)	95% CI	Paired t-test P-value
	Before EST (n=87)	After EST (n=87)			
Q19-Q13. I believe that this patient may benefit from High Frequency Oscillatory Ventilation.	2.48 (0.97)	2.43 (1.10)	-0.06 (0.47)	-0.16 to 0.04	0.25
Q20-Q14. I believe that this patient may benefit from Prone Positioning.	4.22 (0.84)	4.54 (0.63)	+0.32 (0.64)	0.19 to 0.46	**<0.0010**
Q21-Q15. I believe that this patient may benefit from Non-Invasive BiPAP ventilation	1.49 (0.75)	1.48 (0.75)	-0.01 (0.36)	-0.09 to 0.06	0.77
Q22-Q16. I believe that this patient may benefit from the use of Corticosteroids	2.58 (1.07)	2.52 (1.06)	-0.08 (0.56)	-0.20 to 0.04	0.32
Q23-Q17. I believe that this patient may benefit from the use of increased levels of PEEP	3.53 (0.98)	3.38 (1.09)	-0.15 (0.45)	-0.24 to -0.06	**0.0020**
Q24-Q18. I believe that this patient may benefit from ECMO	3.47 (0.85)	3.35 (0.91)	-0.13 (0.64)	-0.26 to 0.01	**0.070**

BiPAP - Bi-Level Positive Airway Pressure; PEEP - Positive End Expiratory Pressure; ECMO – Extra-Corporeal Membrane Oxygenation; EST – evidence summary tool; SD – standard deviation; CI – confidence interval

Aim 7: To evaluate competing versions of the evidence summary tool to determine whether specific elements of presentation of the tool can enhance the use of published research evidence to support clinical decision making.

Competing versions of evidence summary tools

The differences between the competing versions of the evidence summary tools were minimal, and restricted to two sections.

In the first section titled *Prone Positioning in ARDS saves lives*, the evidence-summary tool emphasising evidence from meta-analyses contained the statement "*This is supported by a significant mortality reduction in two well conducted meta-analyses including 6 RCTs enrolling a total of 1,016 patients*" whereas the evidence summary tool emphasising evidence from RCTs contained the statement "*This is supported by a significant mortality reduction in a well conducted RCT analysing 466 patients from 27-hospitals and 5 smaller RCTs enrolling an additional 542 patients.*"

In the final section of the evidence summary tool titled *Brief summary of Evidence Reviewed,* the version with an emphasis on meta-analyses contained the statement "*Meta-analyses published in CMAJ and ICM in 2014. The six included RCTs enrolled 22 - 474 patients each. Five RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation. One meta-analysis included all six trials whilst the second focused on adult patients, and included the four trials that were free from major flaws,*" whereas the final version emphasising RCTs contained the statement "*466 patient RCT published in NEJM in 2013. There were no major flaws in this paper. Five additional RCTs enrolled 22 – 344 patients each. Four of these additional RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation.*"

All other sections of the competing evidence summary tools were identical. Figure 8 demonstrates the formatting of the two contrasting sections of the competing evidence summary tools.

Figure 8. Contrasting sections of the different versions of the competing evidence summary tools.

Evidence Summary tool emphasising meta-analyses:

Prone Positioning in ARDS saves lives
To save 1 life you need to prone 6 patients with severe ARDS on low-tidal volume ventilation. This is supported by a significant mortality reduction in two well conducted meta-analyses including 6 RCTs enrolling a total of 1,016 patients.

Brief summary of Evidence Reviewed
Meta-analyses published in CMAJ[2] and ICM[3] in 2014. The six included RCTs enrolled 22 - 474 patients each. Five RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation. One meta-analysis included all six trials[2] whilst the second focused on adult patients, and included the four trials that were free from major flaws.[3]

Evidence summary tool emphasising RCTs:

Prone Positioning in ARDS saves lives
To save 1 life you need to prone 6 patients with severe ARDS on low-tidal volume ventilation. This is supported by a significant mortality reduction in a well conducted RCT analysing 466 patients from 27-hospitals and 5 smaller RCTs enrolling an additional 542 patients.

Brief summary of Evidence Reviewed
466 patient RCT[1] published in NEJM in 2013. There were no major flaws in this paper. Five additional RCTs enrolled 22 - 344 patients each. Four of these additional RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation.[2,3]

Results of randomised evaluation

A total of 62 participants were randomised to receive the RCT-based evidence summary tool (RCT group), and 60 participants were randomised to receive the systematic review / meta-analysis based evidence summary tool (MA group).

Seventy-one percent (44/62) of the RCT group returned their questionnaires and 81.7% (49/60) were returned by the MA group (p=0.24).

Baseline balance

Demographics

The mean age of respondents was not significantly different between the RCT group and the MA group (49.2 vs. 49.9, P=0.75). There was no significant difference in the balance of gender (29/33 vs. 33/38 males, P=0.90) or primary country of residence (P=0.41, (see Figure 9 and Figure 10). Table 39 reports complete details.

Research experience

The groups did not differ significantly with respect to any aspect of *research experience*. Complete details by group for formal research training or qualification, along with EBM training or qualification can be found in Table 40.

Research use

There was a significant difference in the reported frequency of *reading* published systematic reviews/meta-analyses between groups, with responses indicating the RCT group *read* systematic reviews more often than those randomised to the MA group (mean frequency score 3.93 vs. 3.53, P=0.016). There were no other significant differences in any aspect of the frequency of research *read* between the two randomised groups. There were also no significant differences between groups with regards to the frequency of using a variety of research resources to guide clinical practice decisions. See Table 41 and Table 42 for complete details.

Research attitudes

There were no significant differences between groups with regards to their attitudes towards using research to guide practice decisions, as shown in Table 43.

Appropriate use

The *appropriate use* metric could be calculated for 42 /42 participants allocated to the RCT group and 45/45 participants allocated to the MA group. No significant difference was found between groups with regards to *appropriate use* (35/42 vs. 38/45, P=0.89).

Baseline belief in the benefit of specific clinical interventions

A clinical case-based scenario was developed that outlined a typical ICU patient presenting with a clinical condition that would benefit from treatment with the intervention 'prone positioning' as summarised in the evidence summary tool.

"Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status."

Prior to reading the assigned evidence summary tool there was no significant difference between groups (mean score 4.31 vs. 4.13, P=0.33) with regards to the *strength of agreement* with the statement that the patient in the clinical scenario would benefit from prone positioning.

Prior to reading the assigned evidence summary tool, there was a significant difference between groups with regards to their *strength of agreement* with statements regarding benefits from Corticosteroids (mean score 2.33 vs. 2.80, P=0.042) and an increased level of PEEP (mean score 3.86 vs. 3.22, P=0.0020).

Primary outcome: Differences between groups

Univariable analysis

After reading the assigned evidence summary tool there was no significant difference between groups on univariable analysis (mean score 4.57 vs. 4.51, P=0.66) with regards to the *strength of agreement* with the statement that the patient in the clinical scenario would benefit from prone positioning.

Multivariable analysis controlling for baseline imbalance

After controlling for potential confounders identified as being in imbalance at baseline, backwards elimination stepwise regression revealed there was no significant difference between groups with regards to *strength of agreement* with the statement that the patient in the clinical scenario would benefit from prone positioning, (difference between groups 0.016, P=0.91).

Potential confounders offered to the multivariable model based on univariable analysis of imbalance included:

Q9(a): Attendance at a short EBM course of workshop (P=0.077)

Q11(e): Frequency of *reading* systematic review/meta-analysis (P=0.016)

Q16: Baseline belief in the benefits of corticosteroids (P=0.042)

Q17: Baseline belief in the benefits of increased levels of PEEP (P=0.0020)

Only variables with a multivariable P-value less than 0.05 were retained by the stepwise elimination procedure. Study group was forced to remain in the model at all steps.

The final multivariable model included the following statistically significant variables:

Q16: Pre-existing belief in the benefits of corticosteroids (P=0.014)

Q17: Pre-existing belief in the benefits of increased levels of PEEP (P=0.010)

Complete details of the final model are reported in Table 45.

Figure 9 RCT group primary country of residence

- Australia (n=4)
- Brazil (n=0)
- Canada (n=3)
- Germany (n=2)
- Greece (n=0)
- India (n=2)
- Italy (n=1)
- Japan (n=0)
- Netherlands (n=2)
- New Zealand (n=2)
- Pakistan (n=0)
- Portugal (n=1)
- Saudi Arabia (n=2)
- Slovakia (n=2)
- South Africa (n=0)
- Spain (n=2)
- Sweden (n=0)
- United Kingdom (n=3)
- United States (n=7)
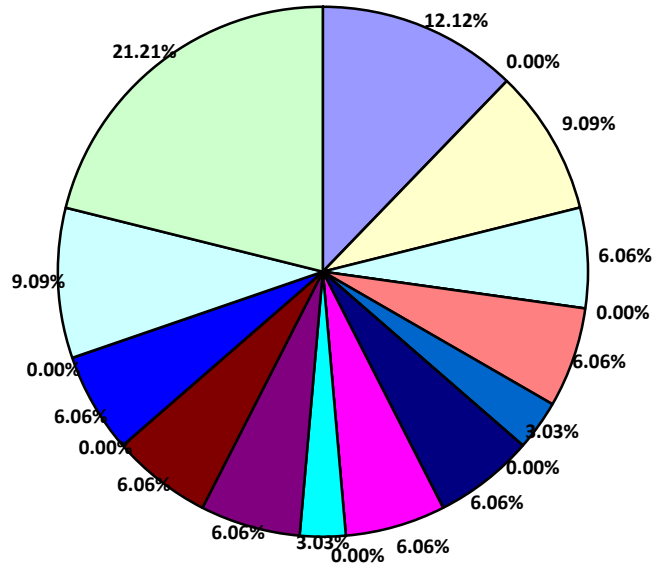
Figure 10 MA Group primary country of residence

- Australia (n=7)
- Brazil (n=1)
- Canada (n=2)
- Germany (n=2)
- Greece (n=2)
- India (n=2)
- Italy (n=2)
- Japan (n=1)
- Netherlands (n=0)
- New Zealand (n=1)
- Pakistan (n=1)
- Portugal (n=3)
- Saudi Arabia (n=0)
- Slovakia (n=1)
- South Africa (n=1)
- Spain (n=0)
- Sweden (n=2)
- United Kingdom (n=1)
- United States (n=8)
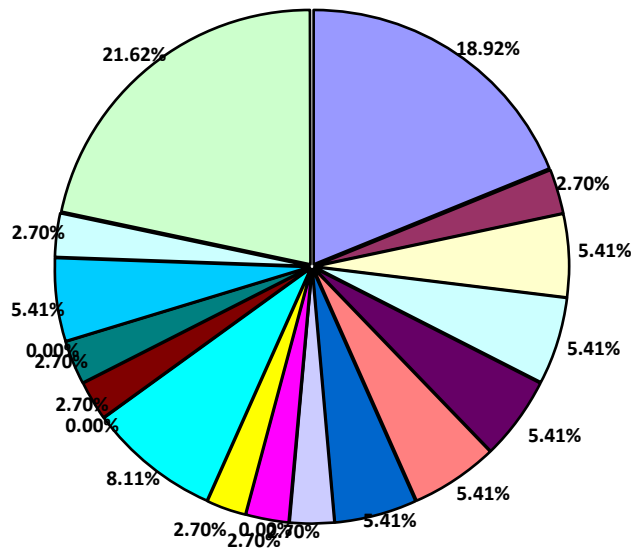
Table 39 Baseline balance: Demographics

Variable	RCT Group (N=44)	MA Group (N=49)	P-value
Q1. Gender - male, percent (n/N)	87.9% (29/33)	86.8% (33/38)	0.90
Q2. Age in years, mean (SD)	49.21 (10.53) n= 33	49.94 (8.20) n=36	0.75
Q4. Years working in ICU, mean (SD)	20.61 (10.22) n= 33	19.51 (9.66) n=37	0.65

ICU - intensive care unit; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group; SD - standard deviation; n/N - number of reported events/Number of total responses

Table 40 Baseline balance: Research experience

	RCT Group	MA Group	P-value
Q5. Academic appointment held at a university, percent (n/N)	42.4% (14/33)	42.1% (16/38)	0.83
Q6. Weekly CME hours, mean (SD)	6.48 (4.22) n=33	5.92 (3.80) n=37	0.59
Q7. Current primary work role: percent (n/N)			
Part time ICU, primary specialty other field	24.4% (10/41)	26.7% (12/45)	
Full time ICU specialist	61.0% (25/41)	40.0% (18/45)	
ICU trainee	0% (0/41)	4.4% (2/45)	
Nurse	4.9% (2/41)	8.9% (4/45)	
Dietitian	0% (0/41)	0% (0/45)	0.23
Physiotherapist	0% (0/41)	0% (0/45)	
Occupational therapist	0% (0/41)	0% (0/45)	
Respiratory therapist	0% (0/41)	4.4% (2/45)	
Pharmacist	0% (0/41)	4.4% (2/45)	
Other	9.8% (4/41)	11.1% (9/45)	
Q8. Level of training or qualification in research[*]	**RCT Group** percent (n/N)	**MA Group** percent (n/N)	**P-value**
Research Fellowship[*]	16.7% (7/42)	11.1% (5/45)	0.46
Formal Research Methodology Course[*]	16.7% (7/42)	26.7% (12/45)	0.26
Graduate Level Research Methodology Course[*]			
Graduate Certificate	2.4% (1/42)	4.4% (2/45)	0.60
Graduate Diploma	2.4% (1/42)	4.4% (2/45)	0.60
Masters	4.8% (2/42)	13.3% (6/45)	0.17
PhD	7.1% (3/42)	4.4% (2/45)	0.59
No formal research qualification	61.9% (26/42)	48.9% (22/45)	0.23
Q9. Level of training or qualification in EBM[#]	**RCT Group** percent (n/N)	**MA Group** percent (n/N)	**P-value**
Non-university course[#]	26.2% (11/42)	44.4% (20/45)	**0.077**
McMaster University EBM course[#]	0	0	
University course[#]	16.7% (7/42)	8.9% (4/45)	0.28
No formal EBM training	57.1% (24/42)	51.1% (23/45)	0.58

CME - continuing medical education; EBM – Evidence Based Medicine; PhD – Doctor of Philosophy; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group; n/N - number of reported events/Number of total responses

*respondents able to select more than one level of training or qualification in research
#respondents able to select more than one level of training or qualification in EBM

Table 41. Baseline balance: Frequency of research *read*

	Mean Score (SD)		
	RCT Group (N=42)	**MA Group** (N=45)	**P-value**
Q10. How often do you use the concepts of EBM in your clinical practice?	4.33 (0.82) (n=42)	4.07 (0.77) (n=43)	0.13
Q11: How often do you read the following:			
Published RCTs	4.05 (0.80)	4.02 (0.72)	0.88
Published EBGs	3.79 (0.92)	3.80 (0.84)	0.94
Published systematic reviews/meta-analyses	3.93 (0.71)	3.53 (0.79)	**0.016**
Evidence summaries	3.60 (0.96)	3.53 (0.92)	0.76
Information in Cochrane Library	3.05 (0.94)	3.07 (0.81)	0.92
Textbooks	2.71 (1.02) (n=42)	3.02 (1.15) (n=41)	0.20

EBM – evidence based medicine; RCTs – randomised controlled trials; EBGs – evidence based guidelines; SD – standard deviation; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group

Table 42. Baseline balance: Frequency of research *used* to guide decisions

Allowable responses: *Never* (Score 1); *Rarely* = once or twice a year (Score 2); *Sometimes* = every month or so (Score 3); *Often* = every week or so (Score 4); *Very often* = every day or so (Score 5).

Q12: How often do you use the following information sources to guide decisions in your clinical practice?	Mean Score (SD)		P-value
	RCT Group (N=42)	MA Group (N=45)	
Published EBGs	4.10 (0.79)	3.98 (0.84)	0.50
Results of an RCT	4.05 (0.80)	3.93 (0.81)	0.51
Results of a systematic review/meta-analysis	3.76 (0.98)	3.60 (1.01)	0.45
Results of Cochrane review	3.38 (0.83)	3.09 (1.00)	0.14
Advice given by colleague	3.33 (0.75)	3.07 (0.96)	0.16
Textbook information	3.05 (0.99)	3.29 (1.01)	0.26
Evidence summary journals	3.14 (1.12)	3.16 (1.02)	0.96
Information from Google search	3.26 (0.96)	2.98 (1.10)	0.20

EBGs – Evidence Based Guidelines; RCTs – Randomised Controlled Trials; SD – standard deviation; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group

Table 43. Baseline balance: Research attitudes

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5)

	Mean Score (SD)		
	RCT Group (N=42)	**MA Group** (N=45)	**P-value**
Q25. My feeling towards using the results of an RCT to guide my clinical practice are positive	4.38 (0.54)	4.24 (0.71)	0.31
Q26. My feelings towards using the results of a systematic review/meta-analysis to guide my clinical practice are positive	4.15 (0.69) (n=41)	4.16 (0.80) (n=45)	0.96

RCT – randomised controlled trial; SD – standard deviation; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group

Table 44. Baseline balance: Belief in the benefit of specific clinical interventions

Allowable responses: *Strongly disagree* (Score 1); *Disagree* (Score 2); *Neutral* (Score 3); *Agree* (Score 4); *Strongly agree* (Score 5).

| | Mean Score (SD) | | |
	RCT Group (n=42)	MA Group (n=45)	P-value
Q13. I believe that this patient may benefit from High Frequency Oscillatory Ventilation.	2.36 (0.96)	2.60 (0.99)	0.25
Q14. I believe that this patient may benefit from Prone Positioning.	4.31 (0.72)	4.13 (0.94)	0.33
Q15. I believe that this patient may benefit from Non-Invasive BiPAP ventilation	1.45 (0.74) (n=42)	1.52 (0.76) (n=44)	0.67
Q16. I believe that this patient may benefit from the use of Corticosteroids	2.33 (1.07)	2.80 (1.04)	**0.042**
Q17. I believe that this patient may benefit from the use of increased levels of PEEP	3.86 (0.93)	3.22 (0.93)	**0.0020**
Q18. I believe that this patient may benefit from ECMO	3.57 (0.89)	3.38 (0.81)	0.29

BiPAP - Bi-Level Positive Airway Pressure; PEEP - Positive End Expiratory Pressure; ECMO – Extra-Corporeal Membrane Oxygenation; SD – standard deviation; RCT group – randomised controlled trial summary tool intervention group; MA group – meta-analysis summary tool intervention group

Table 45. Final Multivariable Model – Outcome is belief in the benefit of prone positioning (Q20)

Variable	Parameter Estimate	SE parameter estimate	P-value
RCT vs. MA group	0.016	0.14	0.91
Q16 corticosteroids	0.15	0.061	0.014
Q17 increased PEEP	0.18	0.069	0.010

Q16 - I believe that this patient may benefit from the use of Corticosteroids, before reading the evidence summary tool; Q17- I believe that this patient may benefit from the use of increased levels of PEEP, before reading the evidence summary tool; SE – standard error

Aim 8: To investigate whether clinician-level factors, research experience, characteristics of research use and research attitudes predict the likelihood of practice change in response to using an evidence summary tool.

To identify clinician-level factors that were associated with a *change in the strength of belief* in the benefits of prone positioning in response to viewing an evidence summary tool, multivariable least squares regression analysis was conducted. The primary outcome for this analysis was the continuous variable *change in the strength of belief*.

Factors under study were identified for evaluation in multivariable regression if the univariable P-value was less than 0.10. Backwards stepwise elimination was used to develop a final model to identify all statistically significant independent predictors of change in the strength of belief.

Univariable analysis

The following factors were identified as candidates for evaluation in multivariable regression based on a univariable regression P-value less than 0.10. These factors were related to an *increase* in the strength of belief in the benefits of prone positioning: *lower* frequency of reading information in Cochrane Library (P=0.094), *lower* frequency of reading published meta-analyses (P=0.070), *lower* frequency of reading evidence summary journals (P=0.078), *lower* frequency of using evidence summary journals (P=0.015), *weaker* pre-existing belief in the benefits of prone positioning (P<0.0001), *stronger* pre-existing belief in the benefits of corticosteroids (P=0.061), *less positive feelings* towards using RCTs to guide practice (P=0.0015), *less positive feelings* towards using systematic review/ meta-analyses to guide practice (P=0.11).

For complete details of the univariable relationships between all clinician-level factors, measures of research experience, characteristics of research use and research attitudes with

change in strength of belief in the benefits of prone positioning, see Table 46, Table 47 and

Table 48.

Multivariable analysis

All variables with a P-value less than 0.10 from the univariable analysis were included

in a comprehensive multivariable model. After backwards stepwise elimination of non-

significant variables, the following variables remained statistically significantly independently

associated with a change in the belief in the benefits of prone positioning. These factors were

associated with an *increase* in the strength of belief the benefits of prone positioning:

Lower pre-existing belief in the benefits of prone positioning (P=0.030),

Higher pre-existing belief in the benefits of corticosteroids (P=0.0037).

Complete details of the final multivariable model can be seen in Table 49.

Table 46. Univariable analysis of clinician-level factors and research experience

Variable*	Parameter Estimate	SE parameter estimate	P-value
Q1. Gender – male referent	0.059	0.22	0.79
Q2. Age in years	0.00053	0.0081	0.95
Q3. Country of residence	Compound dummy variable, overall P-value reported		0.27
Q4. Years practising	0.00021	0.0076	0.98
Q5. Academic appointment	0.026	0.15	0.86
Q6. Weekly CME hours	0.029	0.019	0.13
Q7. Current position	Compound dummy variable, overall P-value reported		0.11
Q8. Research training*			
Research Fellowship*	0.18	0.20	0.37
Research Course*	0.075	0.17	0.65
Graduate Degree*	0.33	0.38	0.38
None	0.34	0.29	0.25
Q9. EBM training[#]			
Non-university based[#]	0.049	0.14	0.73
University[#]	-0.26	0.21	0.22
None	-0.087	0.14	0.53

CME- continuing medical education; EBM – Evidence Based Medicine; SE – standard error
*respondents able to select more than one level of training or qualification in research
[#]respondents able to select more than one level of training or qualification in EBM

Table 47. Univariable analysis of research use

Variable	Parameter Estimate	SE parameter estimate	P-value
Q10. How often do you use EBM?	-0.026	0.088	0.77
Q11: How often do you read the following:			
Published RCTs	-0.10	0.091	0.27
Information in Cochrane Library	-0.13	0.078	**0.094**
Textbooks	-0.013	0.066	0.84
Published EBGs	-0.018	0.079	0.82
Published Meta-analyses	-0.16	0.088	**0.070**
Evidence summaries	-0.13	0.073	**0.078**
Q12: How often do you use the following to guide clinical decisions:			
Evidence summary journals	-0.16	0.063	**0.015**
Advice given by colleague	0.084	0.079	0.29
Textbook information	-0.091	0.068	0.19
Results of a Cochrane review	-0.10	0.074	0.18
Results of an RCT	-0.067	0.086	0.44
Published EBGs	0.018	0.085	0.83
Information from Google	-0.089	0.066	0.18
Results of a Meta-analysis	-0.094	0.069	0.18

EBM – Evidence Based Medicine; RCT's – Randomised Controlled Trials; EBGs – Evidence Based Guidelines; SE – standard error

Table 48. Univariable analysis of research attitudes

Variable	Parameter Estimate	SE parameter estimate	P-value
Pre-existing belief in benefits of specific clinical interventions for the patient-case described in the clinical scenario.			
Q13: High frequency oscillatory ventilation	0.055	0.071	0.44
Q14: Prone positioning	-0.51	0.061	**<0.0001**
Q15: Non-invasive BiPAP	0.0059	0.073	0.94
Q16: Corticosteroids	0.12	0.063	**0.061**
Q17: Increased PEEP	0.051	0.071	0.47
Q18: ECMO	0.013	0.082	0.87
Q25. Positive feelings towards using the results of an RCT to guide my clinical practice	-0.34	0.10	**0.0015**
Q26. Positive feelings towards using the results of a systematic review/meta-analysis to guide my clinical practice	-0.15	0.092	0.11

BiPAP - Bi-Level Positive Airway Pressure; PEEP - Positive End Expiratory Pressure; ECMO – Extra-Corporeal Membrane Oxygenation; RCT – Randomised Controlled Trial; EST – evidence summary tool; SE – standard error

Table 49. Final Multivariable Model: Outcome is *increase* in the belief of the benefit of prone positioning

Variable	Parameter Estimate	SE parameter estimate	P-value
Q14: Strength of pre-existing belief in benefits of prone positioning	-0.52	0.058	0.030
Q16: Strength of pre-existing belief in benefits of corticosteroids	0.14	0.046	0.0037

Q14 - I believe that this patient may benefit from the use of prone positioning, *before* reading the evidence summary tool; Q16- I believe that this patient may benefit from the use of corticosteroids, *before* reading the evidence summary tool; SE – standard error

DISCUSSION

Attitudes towards research amongst intensive care specialists from Australia and New Zealand.

Quantitative mail-out questionnaire survey design

Consideration was given to the advantages and disadvantages of using a mail out self-administered survey. The use of this type of instrument enabled a geographically widespread population to be surveyed in a cost effective manner.[107] Mail out questionnaires offer a lower cost option when compared to other methods such as telephone or face-to face interviews[108] and this was considered an important advantage to the limited budget of our study.

The success of self-administered surveys can be restricted if literacy levels are of concern in the intended survey population.[107] This was deemed unlikely to impact on completion rates in our study. The intended study population were registered medical professionals with assumed acceptable levels of literacy.

Formal validity studies for the McColl[34] questionnaire instrument could not be found, however this questionnaire has been used to guide the development of numerous other studies,[35, 40, 42-45, 51] with consistent and similar results between studies demonstrating reliability. To ensure content validity of our instrument, we reviewed published questionnaires retrieved from the literature search, with a list of recurrent themes, topic areas and common questions collated. Selection and wording of our questions was based around the findings of the review of existing questionnaires to maintain construct validity.

The Dillman Total Design Method advocates mail and telephone survey techniques that focus on social etiquette and personal attention in order to maximise response rates.[93, 98] In general, the Dillman Total Design Method consists of two steps. In the first step, the investigator identifies aspects of the survey that are likely to influence the overall quality or quantity of responses and ensures each aspect of the survey is viewed by the potential recipient

as interesting, useful and easy to answer. The Dillman method also places an emphasis on establishing the legitimacy of the survey and creating trust.

Utilising the framework provided by Dillman's Total Design Method, careful attention was given to the wording of the cover letter to convey the importance of the project and to ensure that the study investigators' appreciation of the time and effort of respondents was clearly communicated. Support of the local intensive care professional college (CICM) was gained, thus increasing legitimacy and trust.

In addition to the initial time and effort placed on the design and wording of each question, pilot testing provided a formal process that allowed us to alter the questionnaire's design and wording one last time, in response to feedback from actual potential recipients.

Survey response rate

In line with the Dillman Total Design Method,[109] following the initial mail out of the survey packages in January 2011, we conducted a total of three mail outs. Dillman and colleagues proposed the use of three follow-up 'waves' to increase response rates to mail out questionnaires,[109] with suggestions in the literature that each additional mail reminder yields about 30-50% of the initial responses.[110] Persistence in the conduct of follow-up mail outs allowed us to improve our response rate from 30% after the first mail out to a final overall response rate of 56%.

Another effective method proposed to increase response rates to postal questionnaires documented in the literature is the use of financial incentives, with a Cochrane review suggesting response can be doubled with the use of financial incentives.[95] Due to funding limitations, we were unable to consider the use of financial incentives and it is unclear if this may have had an effect on our response rate.[111]

Despite optimal survey methodology we did not reach our desired response rate of 70%. However, our response rate is similar to rates achieved in other contemporaneous

physician surveys with similar design.[112, 113] Physicians appear to be a particularly difficult group to survey, with a review by Asch *et al.* finding that compared to other groups, physicians are the poorest responders to surveys.[112] In their review, response by group was evaluated within 321 surveys that included groups such as physicians, dentists, nurses, patients, other health care workers and administrators. Within 68 surveys that involved only physicians, the mean response rate was 54%, which was significantly lower than all other professional groups (p=0.001). This is consistent with our response rate and serves to reinforce the commonality of the difficulties we faced in maximising response rates within our survey.

Item response rates

The item response rate for individual questions was generally very good, with the majority of questions achieving response rates greater than ninety-five percent. We would suggest this further supports the value of the Dillman Total Design Method,[109] and the emphasis it places on design, wording and pilot testing to make each individual question easy to understand and answer.

Sampling frame and characteristics of non-responders

The CICM is a medical specialty college with statutory responsibilities for specialist training and education in the field of intensive care medicine in Australia and New Zealand. The CICM maintains a complete list of accredited practicing intensive care specialists in Australia and New Zealand. Direct use of this registration list minimises non-coverage error by ensuring all members of the population to be studied had a chance of being selected into the study sample.[93, 108]

A comparison of responders and non-responders was not conducted. We were unable to access any identifying details of CICM members and therefore we could not determine if our sample was truly representative of all members. Our sample was similar in regards to mean age and gender composition seen in similar surveys of physicians practicing in this field.[39, 42, 43, 51]

However, it is possible that intensive care specialists with an interest in academia and research may have been more inclined to respond to our survey mail out, and this could be a potential source of non-response bias if this group was over-represented in responders.[108] We interpreted our results with caution based upon an understanding of this potential source of bias.

Technical knowledge

We are unaware of any previous surveys that have documented technical knowledge of research use amongst groups of intensive care practitioners. Thus we are unable to make comparisons to intensive care clinicians from different geographic locations or practice settings, however, it may still be useful to briefly compare and contrast key aspects of our survey against different surveys conducted amongst specialist groups within other fields of medicine.

Consistent with the positive attitudes and acceptable levels of knowledge expressed by respondents to our survey, the majority of published studies show generally positive attitudes towards the use of research evidence to guide clinical practice.

Previously published surveys have often assessed knowledge based upon a *self-reported understanding* of terms.[34, 45] Self-reported understanding is elicited by asking a question such as "Could you explain the term Odds Ratio to a colleague? – Yes or No." Relying on self-reported understanding can be an unreliable measure of *actual* knowledge, as demonstrated by Young *et al.*[114]

In 2002 Young *et al.* conducted a study of Australian general practitioners and compared self-reported understanding to *actual* knowledge.[35, 114] In this study, self-reported understanding of seven research related terms was assessed and then the investigators conducted structured interviews with all participants and asked them to explain the seven terms out loud. For all seven terms, self-reported understanding was found to be significantly higher than actual knowledge.

In consideration of the results of Young et *al.*'s validation study,[114] we chose to assess *actual* knowledge in our study. Despite this technical aspect of our knowledge assessment, respondents demonstrated levels of actual knowledge consistent with previous studies across many different specialist groups within other fields of medicine.[34, 35, 39, 44, 45, 115-117]

Structured hierarchies of research evidence vs. clinician preferences

There appears to be a gap between the type of research evidence that authoritative bodies are recommending that clinicians should use to support clinical decisions and the type of research evidence that clinicians prefer to use. Key authoritative bodies have proposed structured hierarchies of research evidence that consistently promote systematic reviews and meta-analysis as the 'most reliable' source of evidence to support clinical decision making.[52, 53] Interestingly, respondents to our survey consistently ranked RCTs as their most preferred source of evidence to support clinical decision making, whilst systematic reviews and meta-analysis from the Cochrane library ranked as the *least frequently read* and the *least frequently used* type of evidence.

A preference for RCTs over systematic reviews and meta-analyses is consistent with other published studies, with clinicians from many different specialist groups within other fields of medicine expressing higher levels of trust in RCTs.[35, 36, 44] Indeed, in some studies half of the respondents reported not even being aware of the existence of the Cochrane library[34, 43, 44] whilst in other studies almost all respondents reported that they *never* used information from the Cochrane library to help in clinical decision making.[39, 51]

Clearly, research is needed to determine whether this divergence between the type of research evidence that is being *promoted* by authoritative bodies (systematic reviews and meta-analyses) and the type of research evidence that is preferred by clinicians (RCTs) contributes towards creating evidence-practice gaps.

Strengths and limitations

We utilised a simple random sampling technique to obtain our study sample. The CICM registration list was the most comprehensive list available of practising intensive care specialists and utilisation of this list maximised the chance of ensuring all the target population had a chance of selection in our study. These techniques serve to increase the ability to generalise our results to other intensive care specialists. However, it is possible intensive care specialists with positive attitudes towards published research evidence, such as those with academic affiliations, would be more likely to respond to a survey regarding research evidence. We cannot exclude that this may have biased our survey and impacted on external validity.

Demographic data regarding non-responders was not available when evaluating our response rate, as such we were unable to compare non-responders to responders. It was not possible to assess or address any potential non-responder bias and determine impact on the external validity of our findings. The results of our survey may therefore not be representative and generalisable to all intensive care specialists. Thus we have been conservative in the interpretation of our results.

We conducted a rigorous and methodologically sound mail out survey. Whilst all attempts were made to minimise bias through use of The Dillman Total Design Method[109] it is possible that bias is present based upon the order, wording and framing of the questions contained in our questionnaire.

Appropriate use of research evidence amongst intensive care specialists from Australia and New Zealand.

There are few repeatable objective definitions published regarding *appropriate use* of published research evidence in clinical practice. A survey conducted in Italian physicians by De Vito *et al*. provides a working template of *appropriate use,* defined as to read sometimes, often or very often RCT's and meta-analyses, and use the results of RCT's and meta-analyses in

clinical practice.[45] We found no other surveys that utilised such a metric or attempted to quantify appropriate use.[34-36, 39-44, 51, 68, 94]

The face validity of De Vito *et al.*'s definition of appropriate use hinges on the measure of frequency. With the defined frequency set at *sometimes* read and *sometimes* use, a conservative threshold is set. Given the current rapid increase in new publications of primary research evidence in all fields of medicine,[50] it would be difficult to argue for a lower frequency such as *rarely* read and *rarely* use, however, we acknowledge that validation studies are needed to demonstrate whether a higher frequency may be more appropriate (e.g. *often* read and *often* use). Thus, if any bias is present in this metric, because of the low frequency set by the term *sometimes*, we would acknowledge the metric may over-estimate appropriate use rates.

Compared to the original survey conducted by De Vito *et al.*[45], we found that significantly more Australian and New Zealand intensive care specialists responding to our survey met the definition of *appropriate users* of published research evidence compared to the Italian general physicians (88/129 vs. 209/654, P<0.0001). It is possible that this difference may be related to a shift over time in patterns of use as our survey was more recent, or perhaps this finding is explained by practice within a highly specialised area. Setting this significant difference between groups aside, we do find it somewhat concerning that *31.8 percent of responding intensive care specialists do not even read or use research evidence sometimes*.

The intensive care unit is a complex and costly area of the hospital in which the most critically ill patients with the highest risk of death are cared for.[20] With an exponentially expanding research-base demonstrating the desire of the field of intensive care to learn and improve outcomes for patients,[4] we propose it would not be unreasonable to expect *all* intensive care clinicians to read and use research evidence at least *sometimes*. Given the metric we used to estimate appropriate use rates may be biased towards over-estimation, future

research is needed to identify ways to improve the appropriate use of research evidence by intensive care specialists.

Strengths and Limitations

The level of appropriate use of published research evidence in clinical practice was assessed based on the construct previously published in De Vito *et al.*'s large well conducted survey of physicians in Italy.[45] Whilst the components of the tool were not comprehensive, they were easily repeatable and thus enabled us to make a comparison of the levels of self-reported appropriate use found in our population. It must be noted that all measures of appropriate use obtained in this survey were based solely on self-reporting and may therefore not reflect *true* rates of appropriate use. The measure of appropriate use utilised is an arbitrary metric and it is unknown whether it is the most suitable way to measure appropriate use. However, we found no other studies that attempted to quantify or measure rates of appropriate use and therefore this metric is the most reasonable strategy to have used.

De Vito *et al.*'s definition of what constitutes appropriate use appears to be reasonable on face value. By definition, it only requires that you *sometimes* read and use. Clearly, the only other options are *never*, which is certainly inappropriate, and *rarely*. With suggestions that only 30 to 40 percent of practice is based on evidence[10] despite a dramatically expanding evidence base with increasing numbers of studies being published[4] it can certainly be argued that to *rarely* use evidence is just not good enough.

As previously noted, there may be an over-representation of responders with an interest in research in our study, with a seemingly high level of academic affiliations. The level of appropriate use found in our population could potentially over-estimate appropriate use rates in the general population of intensive care specialists in Australia and New Zealand and thus has been interpreted with caution.

Future directions

Although self-reported appropriate use as ascertained by the tool developed by De Vito *et al.*[45] in Australian and New Zealand intensive care specialists was significantly higher than that found in Italian physicians, a moderate level of appropriate use indicates further room for improvement. However, as acceptable levels of appropriate use have not specifically been defined, further research is needed to enable evaluation and establishment of true rates of appropriate use. A clearer definition of what is an acceptable rate of appropriate use is required. More research is needed to assess the depth, reliability and validity of these measures of appropriate use.

Whilst the results of our survey have reinforced ideas from prominent change theorists that promote attitudes and understanding as important components of a successful change management process,[38, 118] there are few studies that actually attempt to measure and quantify these factors in relation to rates of appropriate use of published research evidence. Improving knowledge may lead to a greater understanding of the need to change practice based upon the results of published research evidence. Strategies to improve knowledge such as participation in research training and evidence based medicine courses may be of potential benefit. We recommend that when future research is conducted on measures of appropriate use, measures of the influence and association between attitudes, knowledge and appropriate use be included. This will enable us to gain a better understanding of how these attributes influence the use of published research evidence in clinical practice.

Characteristics associated with the *appropriate use* of published research evidence.

Univariable analysis identified several clinician-level factors that were strongly associated with being an *appropriate user* of published research evidence in clinical practice. These factors included formal training in evidence-based medicine, experiences related to actively running a clinical research project (published as a named primary author, experience

running a funded clinical trial, and having consented a patient for a clinical trial), higher than average CME hours per week, a higher mean knowledge score and more frequent use of a computer to conduct database searches.

One of the founders of the evidence-based medicine movement, David Sackett, defines evidence-based medicine as the "*conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research.*"[63] Clearly, he views evidence based medicine as an active applied science focussed specifically on identifying appropriate research evidence for the primary purpose of supporting individual patient-level clinical decision making. It is somewhat surprising that we fail to find any previous studies that attempt to determine whether training in evidence based medicine results in improved use of research evidence in clinical practice, or whether clinicians who are motivated to identify and use research evidence in practice seek training in evidence based medicine. Interventional studies are needed to evaluate whether providing more training in evidence based medicine to untrained clinicians will increase rates of appropriate use.

It is not surprising to observe that increased CME hours and higher knowledge scores were associated with increased appropriate use rates. As with formal training in evidence based medicine, future interventional studies may be required to determine whether these observed associations are causal.

It was interesting to note that the clinician-level characteristics of age, gender and years practising were not associated with appropriate use. This is consistent with the findings of De Vito *et al.* where Italian physicians' age was not related to appropriate use.[45]

In addition to the above clinician-level factors, univariable analysis identified eight key characteristics of research studies that were identified as being more highly valued by

appropriate users. Appropriate users expressed a preference for methodologically sound, larger multicentre studies conducted in their own health care system. They preferred papers that were clearly written, in a fashion consistent with CONSORT or QUOROM statements. Furthermore, appropriate users valued a paper more highly if it was the second publication on the topic to demonstrate a significant benefit and if the benefit was measured using patient-centred outcomes. Appropriate users also expected a paper to fully explore all possible benefits and harms and present a full economic analysis. It is possible that evidence-practice gaps are more likely to be closed if the supporting research evidence fulfils each of the above identified characteristics. Future interventional studies need to address this hypothesis.

Univariable analysis also identified five potential inhibitory factors that were strongly associated with *not* being an appropriate user. Clinicians who were *not appropriate users* were more likely to report difficulties using MEDLINE and were less likely to be able to find useful papers using MEDLINE. Furthermore, they were more likely to judge known papers as not good enough to guide practice. Clinicians who were *not appropriate users* held a stronger belief that appraising published research papers is not part of their job role, a stronger belief that they do not have enough training in EBM and they had greater difficulty *integrating individual clinical expertise with the best available external clinical evidence from systematic research* because they held a stronger belief that individual patient variation is not accounted for in the results of published research.

It is concerning to observe that any intensive care specialist in Australia and New Zealand currently believes that *appraising published research papers is not part of the job role*. However, because of the nature of the study we conducted, these observed associations may not be causal. This finding may be an artefact of the wording we chose or it may be simply correlated with another more important characteristic. To identify whether any of the

key associations identified above might remain on a potentially casual pathway after controlling for all other interrelationships, we conduced multivariable analysis.

Multivariable analysis

Multivariable analysis of the clinician-level factors, research study characteristics and potentially inhibiting factors distilled the results to three factors that were independently and significantly associated with appropriate use: mean knowledge score; experience running funded clinical trials; and a preference for multicentre projects.

For the two clinician-level factors: mean knowledge score and experience running funded clinical trials; it is difficult to determine the temporal relationship with appropriate use. For example, having better knowledge and more experience running clinical trials may lead to increased frequency of research use. Alternatively, being an appropriate user and as such, a more frequent user of research evidence may lead to a higher level of knowledge or a commitment to contribute to knowledge by running a funded clinical trial. Interventional or prospective cohort studies may help determine this relationship.

Interestingly, the only research study characteristic that remained independently associated with appropriate use was that *the project involved multiple study centres*. This finding is consistent with the published opinions of experts in the field, who clearly express a preference for multicentre trials.[119] Indeed, in their 2009 opinion paper Bellomo *et al.* report multiple examples of single-centre studies with positive results that were contradicted by the conduct of subsequent multicentre definitive trials. Based on the results of our multi-variable regression analysis, conduct across multiple sites may be the single most important study characteristic to emphasise when presenting research evidence to influence practice change. Future studies should be undertaken to investigate the potential importance of this approach to presenting and describing research evidence.

Attitudes towards research amongst a multinational cohort of clinicians with a special interest in intensive care.

Quantitative e-mail questionnaire survey design

A self-administered e-mail questionnaire was selected for this study as it enabled us to survey a geographically widespread population in a cost-effective manner.[107] Compared to postal mail out, e-mail administration greatly reduces costs associated with the conduct of a survey.[120]

The success of self-administered surveys can be restricted due to literacy or language concerns in the intended survey population.[107] Although we expected a significant proportion of respondents to have a primary language other than English, the sampling frame was composed of registered medical professionals who actively participated in an English-language e-mail discussion group (CCM-L: The Critical Care e-mail discussion List). Thus, we expected a good working knowledge of English amongst respondents to complete the questionnaire. Furthermore, the limited budget of the study did not enable us to consider utilising the services of a translator to provide options for completion of the questionnaire in any other language.

To ensure content validity and maintain construct validity we utilised pre-existing questionnaires as the basis for development of the e-mail questionnaire survey for this study[34, 45, 104] and to maximise the quality and quantity of responses, we embraced the Dillman Total Design Method.[93, 98, 109, 111, 121] We carefully constructed a cover letter to participants that conveyed the importance of the project and clearly communicated our appreciation of the time and effort given by respondents to participate. Our cover letter concluded with the statement "since the validity of the results depends on obtaining a high response rate, your participation is crucial to the success of this study." Emphasising the importance of *every* recipient's contribution being important to the success of the survey can directly influence participation.[120]

In order to maximise readability and encourage completion of the questionnaire we paid strong attention to recommendations in the Dillman method regarding formatting and design.[96, 98, 107, 108, 120] The length of the questionnaire was minimised and it was emphasised in the cover letter than the questionnaire should take no longer than five to ten minutes to complete. While the definition of what constitutes a long survey varies among studies, response rates generally increase with shorter questionnaires.[107] To minimise the overall number of pages included in the questionnaire, a separate cover page was not added to the booklet. Other considerations to improve readability included creating a single sided document, minimal use of bulk capital letters, use of headings and sections, and a minimum font size of twelve points throughout the document.

It has been suggested that placing demographics at the beginning of a questionnaire can put respondents off, however a Cochrane review demonstrated that there was no difference in response rates when comparing questionnaires with demographic items first and questionnaires with demographic items last.[95] We chose to place simple demographic questions at the beginning of our document to ease respondents into questionnaire completion. Careful consideration was given to the amount of information collected in demographics in order to minimise reduced response rates from perceived threats to anonymity being maintained.[95]

In addition to the initial time and effort placed on the design and wording of each question, pilot testing provided a formal process that allowed us to alter the questionnaire's design and wording one last time, in response to feedback from actual potential recipients.

Survey response rate

The administration of surveys via e-mail may appear to offer promising advantages such as reduced response time, higher completeness of data, and large cost savings compared to other methods of survey administration.[122, 123] Unfortunately, e-mail surveys of medical professionals are known to be problematic, with low completeness rates and low response

rates.[122, 124, 125] At approximately ten percent, our response rate for this e-mail survey of intensive care clinicians was similar to other e-mail surveys of clinicians in other fields of medicine.

We used design-based approaches to maximise response rates in our study, such as personalised mailings, design-friendly questionnaires, and university sponsorship.[95, 109, 126, 127] Token monetary incentives are known to increase physician response to surveys[113, 128] however the funding limitations of this study meant we were unable to consider offering any financial reward for participation. Instead we appealed to potential participants' professionalism and collegiality in the initial recruitment e-mail.

The repeated encouragement of participation through ongoing follow-up reminders is a well established strategy to maximise response rates.[98, 121] We sent monthly reminder recruitment e-mails to the CCM-L list, with a carefully worded cover letter that outlined the purpose of the study and the importance of each individual's participation. Despite extending our study to a total recruitment period of one year, and maximising the use of strategies to enhance response, we were unable to achieve our desired response rate.

Due to the low response rate of ten percent of the total sampling frame, we exercise caution generalising our results.

Item response rates

Six of the 93 questionnaires were returned to our secure dropbox completely blank. We believe this may have been a technical issue related to the live PDF format of the survey. Although we had undertaken beta-testing with many different hardware platforms and PDF readers, it is possible some respondents used unexpected computing platforms (any flavour of UNIX) with a generic PDF reader. In such a situation, it is possible the completed form failed to save properly, and the unaware respondent submitted the blank form assuming it was completed.

Because of the anonymous process used for secure dropbox submission, we were unable to trace the blank forms back to respondents to obtain complete data. When working with new technology, such as an editable Adobe[o] PDF form, it is difficult to predict technical issues that may arise even after extensive beta-testing. Perhaps this technical difficulty could have been overcome through the use of a paper-based survey. However, since we did receive one blank survey form during the conduct of our paper-based survey[104] with a 'protest note' attached, we must also consider the possibility that these six blank PDF responses were also 'protest votes'.

Sampling frame and characteristics of non-responders

The Critical Care Medicine e-mail list (CCM-L) is a free, multidisciplinary electronic-mail discussion group serving multinational subscribers, which has been actively running since 1994. It has over 1,000 voluntary members from more than 50 different countries.[105] Selection of the CCM-L as the sampling frame was based on convenience, as it provided access to clinicians with an interest in intensive care from throughout the world.

A comparison of the basic characteristics of responders and non-responders could not be conducted. We were unable to access any identifying details of CCM-L members and therefore we could not determine if our sample was truly representative of all members. Our sample was similar in regards to mean age and gender composition seen in similar surveys of physicians practicing in this field.[39, 42, 43, 51] Furthermore, the basic demographics of responders to this survey were similar to the basic demographics of responders to our mail survey of intensive care clinicians from Australia and New Zealand.[104]

However, it is possible that intensive care specialists with an interest in academia and research may have been more inclined to respond to our e-mail survey, and this could be a potential source of non-response bias if this group was over-represented in responders.[108] We

---

[o] Adobe Systems, San Jose, CA, USA.

interpreted our results with caution based upon an understanding of this potential source of bias.

Structured hierarchies of research evidence vs. clinician preferences

Like the Australian and New Zealand intensive care specialists who responded to our mail survey,[104] respondents from this international cohort of clinicians with an interest in intensive care consistently ranked RCTs as their most preferred source of evidence to guide clinical decision making. This preference for RCTs over systematic reviews appears to be consistently expressed by clinicians,[35, 36, 44] yet all theoretical research hierarchies rank RCTs below systematic reviews as a trusted source of evidence. [52, 53, 57]

Despite the methodological rigour offered within Cochrane reviews, information from the Cochrane library ranked as one of the most underutilised resources, with only textbooks ranking lower from a list of six information sources read by the respondents to our e-mail survey. Again, this is consistent with the underutilisation of the Cochrane library reported by surveys conduct amongst many specialist groups within other fields of medicine.[34, 43, 44]

This clear discordance between hierarchies of evidence and clinicians preferences highlights the need for further research to evaluate the effectiveness of influencing change using RCTs compared to systematic reviews and meta-analyses.

Appropriate use of research evidence amongst a multinational cohort of clinicians with a special interest in intensive care.

We found an appropriate use rate of 83.9% (95% CI, 76.2 to 90.9%) according to the metric set out by De Vito *et al*.[45] Based on a direct comparison of 95% confidence intervals, appropriate use was significantly higher in responders from this multinational cohort compared to responders to our survey conducted amongst Australian and New Zealand intensive care specialists 68.2% (95% CI, 59.4 to 76.1%).[104]

The CCM-L provides an online e-mail discussion forum for clinicians with a special interest in intensive care. Participants self-select for membership in this group. Although the main focus of CCM-L is to enable clinical consultation with peers to solve current bedside patient problems, CCM-L also provides a forum to discuss the clinical relevance of the latest breaking research. Our mail survey of intensive care specialists in Australia and New Zealand identified that higher CME time was associated with respondents being identified as an appropriate user of research evidence.[104] Although formal CME credits are not offered, participation in CCM-L could be regarded as a CME related activity. Thus, using a CME related special interest group such as CCM-L as the sampling frame could be expected to result in a population of responders who were more prone to being classified as appropriate users of research.

Strengths and limitations

With blanket e-mails to all member of CCM-L, we attempted a census style approach to sampling that had the potential to include all members of our sampling frame. Although our overall response rate was low, it was consistent with previous e-mail based surveys of medical professionals. Our questionnaire design was based on well-established methodology known to improve the quality and quantity of responses.[109] Given our final response rate, we were conservative in the generalisation of our results. Nevertheless, based on our robust and sound methodological design, internal validity was preserved.

A reporting bias occurs when there is selective revelation of information by study participants.[49] For example, physicians consistently state they value practice recommendations made by credible clinical practice guidelines[94,35,41,43] and self-report their provision of care complies with practice recommendations made by credible clinical practice guidelines.[44,35,114] However, audits of actual clinical practice demonstrate that clinicians' behaviours are not consistent with practice recommendations made by credible clinical practice guidelines.[6]

Underuse evidence-practice gaps arising from the difference between what clinicians say they do and what they actually do have been documented by numerous studies.[13,15,18]

Because our survey relies on self-reporting of attitudes towards practice, we caution the reader that our results may over-estimate the actual change in practice that could be achieved through the use of an evidence summary tool. We strongly recommend that future research evaluates the influence of an evidence summary tool on actual practice in the clinical environment in order to remove the potential for a reporting, or say-do, bias.

Using an evidence summary tool to improve research use.

We developed a case-based scenario that presented a realistic patient in order to create an experiential learning situation. Theories of adult learning promote experiential learning situations as an effective method of transferring information.[129]

The novel information identified for inclusion in the evidence summary tool was based on a thorough review of the literature in the field of intensive care medicine. At the time of commencement of our study in August 2015, current best evidence to support prone positioning of patients with severe ARDS was based on a multicentre RCT that clearly demonstrated a statistically significant and clinically meaningful reduction in mortality.[5]

The results of this multicentre RCT, published two years prior to our study, had not yet been incorporated into the one major clinical practice guideline that recommended prone positioning for patients with severe ARDS. In 2015, the most recent version of the Surviving Sepsis Campaign guideline was the '2012 update.'[24] When published in 2013, the authors of the '2012 update' made a *weak* recommendation using the wording "We suggest prone positioning in sepsis-induced ARDS patients with a PaO_2/FiO_2 ratio ≤ 100 mm Hg in facilities that have experience with such practices.*"* This recommendation is formally recognised as weak, as it was only supported by Grade 2B evidence at the time ('2' indicates a weak recommendation and 'B' indicates moderate evidence).[24]

In the '2016 update' of the Surviving Sepsis Campaign guideline, when published in 2017, the recommendation for prone positioning was upgraded to *strong* using the wording "We recommend using prone over supine position in adult patients with sepsis-induced ARDS and a PaO_2/FiO_2 ratio <150 (strong recommendation, moderate quality of evidence)."[26] The upgrading to a *strong* recommendation and the explicit change in the PaO_2/FiO_2 ratio threshold to < 150 mm Hg based on the results of Guerin *et al.'s* 2013 multicentre RCT[5] demonstrate that acceptance of the evidence supporting this clinical recommendation was in dynamic transition during the conduct of our study. Prone positioning was therefore a highly appropriate novel clinical intervention to use for testing the utility of an evidence summary tool.

Change in the belief in the benefits of prone positioning

Reviewing an evidence summary tool that concisely presented objective research evidence supporting the benefits of prone positioning for critically ill patients with severe ARDS resulted in a significant *increase* in the belief that prone positioning would benefit the realistic patient described in our case-based scenario. Interestingly, reviewing the evidence summary tool that concisely presented objective research evidence supporting the benefits of prone positioning also led to a significant *decrease* in the belief that corticosteroids would benefit the realistic patient described in our case-based scenario. Although the evidence summary tool did not even mention corticosteroids, we believe this decrease in belief is entirely consistent with a real change in the acceptance of prone positioning as an appropriate real-world treatment option.

The practice of using corticosteroids to treat patients with sepsis-induced ARDS was commonplace in the early 21st century, and was supported by numerous small RCTs.[130, 131] However, ten years ago the ARDSNet investigators published a large multicentre RCT in the New England Journal of Medicine that failed to demonstrate any benefits of corticosteroids for the treatment of ARDS.[132] The most recent '2016 update' of the Surviving Sepsis Campaign

guidelines, published in 2017, makes no recommendation for the use of steroids in patients with sepsis-induced ARDS.[26] Corticosteroids are cheap and have been used clinically for a long time. Currently, they are most likely to be used by clinicians in patients who have developed ARDS and are very difficult to ventilate, most likely because the clinicians are unaware of, or do not believe in, other proven treatment options. We suggest that our evidence summary tool, which was clearly effective at communicating the appropriateness of prone positioning for the realistic patient described in our clinical scenario, also resulted in prone positioning *replacing* corticosteroids as a competing treatment option and thus significantly reduced the clinicians belief in the possible benefits of corticosteroids for the realistic patient described in the clinical scenario.

We have demonstrated that reviewing an evidence summary tool that concisely describes the research evidence supporting a treatment option can change a clinician's belief in the potential benefits of that treatment. The seminal *transtheoretical model of health behaviour change* proposed by Prochaska and Velicer posits that before health-related behaviour is changed, the individual must be aware of the *need for change* and the *positive benefits of change*.[38] *Belief in the positive benefits of change* achieved by our evidence summary tool therefore may represent the required first steps necessary to achieve actual behaviour change. We strongly recommend additional research to determine whether a change in belief achieved by use of an evidence summary tool can translate into a change in clinical practice behaviours. Although we achieved a change in belief using our evidence summary tool, achieving a change in clinical practice behaviours is considered complex and usually requires a multifaceted intervention.[133] Undertaking such a project was beyond the scope of this current thesis, but our promising results clearly indicate that the use of evidence summary tools requires further evaluation.

Should evidence summary tools promote RCTs or systematic reviews?

By placing systematic reviews and meta-analyses at the top of evidence hierarchies, experts are clearly recommending that clinicians should prefer this type of evidence to support clinical decision making.[52, 53] However, clinicians clearly express a preference for RCTs to inform their decisions.[35, 36, 44, 45, 104] To test whether clinicians are influenced differently by different primary sources of evidence, we developed two subtly different versions of the evidence summary tool. Although both versions of the tool concisely summarised the evidence supporting the benefits of prone positioning, one version emphasised the evidence source as being a multicentre RCT plus additional smaller RCTs whilst the other version emphasised the evidence source as being a multi-trial meta-analysis. Members of CCM-L who volunteered to respond to our survey on attitudes towards research evidence were randomly assigned to receive one of the two competing versions of the evidence summary tool.

Whilst both evidence summary tools increased clinicians' belief in the benefit of prone positioning, we failed to find any differences *between* the two tools. Even after accounting for potential confounding arising because of imbalance in baseline variables, we failed to find a difference between the competing evidence summary tools.

It is possible that we were unable to detect a difference between groups due to the small size of our study. It is also possible that the evidence summary tools were so subtle in the way the evidence-source was emphasised, that no differences exist. Based on our results, the best estimate of a possible difference in effect achieved by the competing evidence summary tools was 0.07 units. The mean magnitude of belief change achieved by both tools was +0.32 units. Although we are unable to comment on whether a value of 0.07 units would be clinically meaningful, we do recommend more research on this issue with larger sample sizes. Data presented in our Results section can serve to guide appropriate sample size calculations for

future research. In addition, we recognise that additional research should determine whether other factors of the evidence summary tool can be optimised to maximise effectiveness.

Who did the evidence summary tool influence?

On univariable analysis, clinician-level factors and research experience were not found to be predictors of the likelihood of change in response to our evidence summary tool. For example there was no relationship between age, gender, number of years practising in intensive care, or weekly CME hours and change in belief of benefit. Likewise research training and EBM training did not predict a change in belief of benefit.

Interestingly, *frequency of reading* and *positive attitudes towards using* different types of evidence were found to influence the magnitude of the change in the belief in benefit. A *lower* frequency of *reading* information from the Cochrane library, meta-analyses and evidence summary journals predicted a *greater* increase in the belief of benefit of prone positioning after reading the evidence summary tool. Furthermore, *less* positive feelings towards *using* RCTs and systematic reviews to guide clinical practice also predicted a *greater* increase in the belief of benefit of prone positioning after reading the evidence summary tool.

These findings are interesting and potentially very important. A *lower frequency of reading* and a *less positive attitude* towards using RCTs and systematic reviews to guide practice change could describe a clinical population who is *less up to date*. In his seminal text book on change management theory, *Diffusion of Innovations*, Everett Rogers proposed that when any population of individuals is presented with a new technology, their initial responses can be broken down into five classes: Innovators; Early adopters; Early majority; Late majority; and Laggards.[118] The term Laggards is used to describe the group that is last to change. Typically, they are described as having an outlook that focuses on the past and how things were done, rather than looking to the future. They are described as being slow to become aware of new innovations and they delay changing until they are absolutely certain that a new

idea or practice will not fail. It is extremely promising that our tool seemed to capture the attention of this group of people, who are typically the last and most difficult in a group to change.

On multivariable analysis, accounting for potential confounding arising from all of the potential predictors identified during univariable analysis, two variables remained statistically significant independent predictors of a change in the belief of benefit of prone positioning. These variables were a *higher* pre-existing belief in the benefit of corticosteroids and a *lower* pre-existing belief in the benefit of prone positioning. Again, we would suggest that these two characteristics identify clinicians who are less up to date.

With regards to the clinical options identified for the realistic patient described in our case-based scenario, we would suggest that treatment with corticosteroids would represent an 'outdated' approach proven to have no effect over ten years ago,[132] whilst prone positioning would represent the approach most recently proven effective in a multicentre RCT.[5] Once again, this fits the profile of a change Laggard: Lack of awareness of new technology and a fixation on past technology.

Context

Despite an awareness that current best research evidence should be used to guide clinical decision making, it is well documented that there is a continuing failure of health care professionals to provide medical care in line with good quality evidence.[10] Situations where good quality evidence is not translated into clinical practice cause significant harm to patients. The overwhelming loss of life attributable to the failure to implement a simple and effective treatment for scurvy in the 18th century is one such astounding example. Despite James Lind successfully demonstrating citrus fruit was an effective intervention to treat scurvy, the use of this simple treatment did not become common practice until 42 years after publication of his results.[7, 8]

Unfortunately modern medicine fares no better, with irrefutable evidence demonstrating that clinical practice is not always guided by the best available evidence. In the United States, in a large study involving over 6,000 patients with a wide range of medical conditions, 45% failed to receive care supported by research evidence.[13] A similar study conducted in Australia produced similar findings: care was based on best evidence recommendations in only 43% of patient encounters.[15] These situations serve to highlight that evidence-practice gaps warrant attention in all fields of medicine.

In the ICU, where patients have a high risk of death[20] and the cost of providing medical care is three times that of the standard hospital patient,[3] evidence-practice gaps have the potential to cause significant patient harm. The number of clinical trials being produced in the field of intensive care medicine is increasing exponentially,[4] yet despite numerous trials demonstrating the effectiveness of life saving clinical interventions, evidence-practice gaps exist.

The landmark ARDSNet low-tidal-volume ventilation trial provides clear evidence supporting a simple life saving intervention for ventilatory management of patients with Acute Respiratory Distress Syndrome in the ICU.[23] The ARDSNet low-tidal-volume ventilation strategy evaluated in this trial significantly reduced mortality rates by 8.8% (31.0% vs. 39.8%, P=0.007) compared to traditional tidal volumes.

Incorporation of the ARDSNet low-tidal-volume ventilation strategy into major international clinical practice guidelines confirms the acceptance of the importance of the results of this trial,[24-26, 30] yet studies evaluating delivery of care clearly demonstrate an evidence-practice gap. Published in 2016, Bellani *et al.* measured the adherence to the ARDSNet low-tidal-volume ventilation strategy in patients with the Acute Respiratory Distress Syndrome.[6] In the 915 critically ill patients objectively diagnosed with the Acute Respiratory Distress Syndrome, 36.3% (332/915) of eligible patients *did not* receive the ARDSNet low-

tidal-volume ventilation strategy. Despite the results of the ARDSNet low-tidal-volume ventilation trial demonstrating that we can save one life by treating just eleven patients with this simple effective life saving intervention, clinicians fail to provide medical care in line with this high quality evidence.

The use of prone positioning in the ICU provides another example of a clear evidence-practice gap where an intervention has proven benefit from a high quality clinical trial. Although Guerin *et al.*'s landmark trial was published in 2013,[5] Bellani *et al.* reported that by 2016, only 16.3% (119/729) of eligible patients actually received prone positioning.[6]

Evidence-practice gaps exist today. Failure to receive beneficial treatment according to the best available evidence results in harm to patients. Despite the known existence of evidence-practice gaps and the associated harms, objective evidence for techniques proven effective at closing evidence-practice gaps is sparse.[61, 134-138] The findings of this thesis take an important first step in the identification of a method that may hold great promise for addressing evidence-practice gaps: the *evidence summary tool*.

With clinicians consistently reporting a preference for RCTs[35, 36, 44, 45, 104] and research demonstrating widespread underuse of systematic reviews and meta-analyses[39, 42, 51, 68, 94, 104] the development and promotion of a structured, succinct and concise *evidence summary tool* offers a promising strategy to increase awareness and acceptance of novel research evidence. Logically, this increased awareness may lead to appropriate practice changes. Thus, evidence summary tools may play an important role in reducing evidence-practice gaps.

REFERENCES

1. National Health and Medical Reseach Council. Research funding statistics and data report. Canberra: NHMRC (Accessed 28-3-2017 at https://www.nhmrc.gov.au/grants-funding/research-funding-statistics-and-data).

2. Halpern NA, Bettes L, Greenstein R. Federal and nationwide intensive care units and healthcare costs: 1986-1992. *Crit Care Med* 1994;22(12):2001-2007.

3. Halpern NA, Pastores SM. Critical care medicine in the United States 2000-2005: an analysis of bed numbers, occupancy rates, payer mix, and costs. *Crit Care Med* 2010;38(1):65-71.

4. Doig GS, Roberts I, Bellomo R. The tens of thousands of lives saved by randomized clinical trials in critical care. *Intensive Care Med* 2015;41(4):701-704.

5. Guerin C, Reignier J, Richard JC et al. Prone positioning in severe acute respiratory distress syndrome. *N Engl J Med* 2013;368(23):2159-2168.

6. Bellani G, Laffey JG, Pham T et al. Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries. JAMA 2016;315(8):788-800.

7. Lind J. A treatise of the scurvy. In three parts. Containing an inquiry into the nature, causes, and cure, of that disease. Together with a critical and chronological view of what has been published on the subject. By James Lind M.D. Edinburgh: Printed by Sands, Murray and Cohran for A. Kincaid & A. Donaldson; 1753.

8. Milne I. Who was James Lind, and what exactly did he achieve. *J R Soc Med* 2012;105:503-509.

9. National Health and Medical Research Council. Evidence-Practice Gaps Report Volume 1: A review of developments: 2004-2007. Canberra: NHMRC (Accessed 27-3-2017 at https://www.nhmrc.gov.au/guidelines-publications/nic48).

10. Buchan H. Gaps between best evidence and practice: causes for concern. *Med J Aust* 2004;180(6 Suppl):S48-S49.

11. National Institute of Clinical Studies. Evidence-Practice Gaps Report (Volume 1). Melbourne: NICS (Accessed 27-03-2017 at https://www.nhmrc.gov.au/guidelines-publications/nic46).

12. Antman EM, Lau J, Kupelnick B, Mosteller F, Chalmers TC. A comparison of results of meta-analyses of randomized control trials and recommendations of clinical experts. Treatments for myocardial infarction. *JAMA* 1992;268(2):240-248.

13. McGlynn EA, Asch SM, Adams J et al. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;348(26):2635-2645.

14. Kemper P, Blumenthal D, Corrigan JM et al. The design of the community tracking study: a longitudinal study of health system change and its effects on people. *Inquiry* 1996;33(2):195-206.

15. Runciman WB, Hunt TD, Hannaford NA et al. CareTrack: assessing the appropriateness of health care delivery in Australia. *Med J Aust* 2012;197(2):100-105.

16. Forsyth G. An enquiry into the drug bill. *Medical Care* 1963;1(1):10-16.

17. Chassin MR, Kosecoff J, Park RE et al. Does inappropriate use explain geographic variations in the use of health care services? A study of three procedures. *JAMA* 1987;258(18):2533-2537.

18. Ellis J, Mulligan I, Rowe J, Sackett DL. Inpatient general medicine is evidence based. A-Team, Nuffield Department of Clinical Medicine. *Lancet* 1995;346(8972):407-410.

19. Dubinsky M, Ferguson JH. Analysis of the National Institutes of Health Medicare coverage assessment. *Int J Technol Assess Health Care* 1990;6(3):480-488.

20. Australia and New Zealand Intensive Care Society. ANZICS Centre for Outcome and Resource Evaluation Annual Report 2014-2015. Melbourne: ANZICS (Accessed 20-12-2016 at http://www.anzics.com.au/Pages/CORE/CORE-Reports.aspx).

21. Rechner IJ, Lipman J. The costs of caring for patients in a tertiary referral Australian Intensive Care Unit. *Anaesth Intensive Care* 2005;33(4):477-482.

22. Moran JL, Peisach AR, Solomon PJ, Martin J. Cost calculation and prediction in adult intensive care: a ground-up utilization study. *Anaesth Intensive Care* 2004;32(6):787-797.

23. The ARDS Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. The Acute Respiratory Distress Syndrome Network. *N Engl J Med* 2000;342(18):1301-1308.

24. Dellinger RP, Levy MM, Rhodes A et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. *Crit Care Med* 2013;41(2):580-637.

25. Dellinger RP, Carlet JM, Masur H et al. Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock. *Intensive Care Med* 2004;30(4):536-555.

26. Rhodes A, Evans LE, Alhazzani W et al. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016. *Intensive Care Med* 2017;43(3):304-377.

27. Fan E, Del SL, Goligher EC et al. An Official American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine Clinical Practice Guideline: Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome. *Am J Respir Crit Care Med* 2017;195(9):1253-1263.

28. Claesson J, Freundlich M, Gunnarsson I et al. Scandinavian clinical practice guideline on mechanical ventilation in adults with the acute respiratory distress syndrome. *Acta Anaesthesiol Scand* 2015;59(3):286-297.

29. Atkins D, Best D, Briss PA et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004;328(7454):1490.

30. Dellinger RP, Levy MM, Carlet JM et al. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock: 2008. *Intensive Care Med* 2008;34(1):17-60.

31. Ranieri VM, Rubenfeld GD, Thompson BT et al. Acute respiratory distress syndrome: the Berlin Definition. *JAMA* 2012;307(23):2526-2533.

32. Sud S, Friedrich JO, Adhikari NK et al. Effect of prone positioning during mechanical ventilation on mortality among patients with acute respiratory distress syndrome: a systematic review and meta-analysis. *CMAJ* 2014;186(10):E381-E390.

33. Beitler JR, Shaefi S, Montesi SB et al. Prone positioning reduces mortality from acute respiratory distress syndrome in the low tidal volume era: a meta-analysis. *Intensive Care Med* 2014;40(3):332-341.

34. McColl A, Smith H, White P, Field J. General practitioner's perceptions of the route to evidence based medicine: a questionnaire survey. *BMJ* 1998;316(7128):361-365.

35. Young JM, Ward JE. Evidence-based medicine in general practice: beliefs and barriers among Australian GPs. *J Eval Clin Pract* 2001;7(2):201-210.

36. Hanson BP, Bhandari M, Audige L, Helfet D. The need for education in evidence-based orthopedics: an international survey of AO course participants. *Acta Orthop Scand* 2004;75(3):328-332.

37. Ajzen I. Attitudes, Personality and Behaviour. 2nd ed. Berkshire: Open University Press; 2005.

38. Prochaska JO, Velicer WF. The transtheoretical model of health behaviour change. *American Journal of Health Promotion* 1997;12(1):38-48.

39. McAlister FA, Graham I, Karr GW, Laupacis A. Evidence-based medicine and the practicing clinician. *J Gen Intern Med* 1999;14(4):236-242.

40. Askew DA, Clavarino AM, Glasziou PP, Del Mar CB. General practice research: attitudes and involvement of Queensland general practitioners. *Med J Aust* 2002;177(2):74-77.

41. Kitto S, Villanueva EV, Chesters J, Petrovic A, Waxman BP, Smith JA. Surgeons' attitudes towards and usage of evidence-based medicine in surgical practice: a pilot study. *ANZ J Surg* 2007;77(4):231-236.

42. Poolman RW, Sierevelt IN, Farrokhyar F, Mazel JA, Blankevoort L, Bhandari M. Perceptions and competence in evidence-based medicine: Are surgeons getting better?

A questionnaire survey of members of the Dutch Orthopaedic Association. *J Bone Joint Surg Am* 2007;89(1):206-215.

43. Sur RL, Scales CD, Jr., Preminger GM, Dahm P. Evidence-based medicine: a survey of American Urological Association members. *J Urol* 2006;176(3):1127-1134.

44. Dahm P, Poolman RW, Bhandari M et al. Perceptions and competence in evidence-based medicine: a survey of the American Urological Association Membership. *J Urol* 2009;181(2):767-777.

45. De Vito C, Nobile CG, Furnari G et al. Physicians' knowledge, attitudes and professional use of RCTs and meta-analyses: a cross-sectional survey. *Eur J Public Health* 2009;19(3):297-302.

46. Hayward RS, Guyatt GH, Moore KA, McKibbon KA, Carter AO. Canadian physicians' attitudes about and preferences regarding clinical practice guidelines. *CMAJ* 1997;156(12):1715-1723.

47. Tunis SR, Hayward RS, Wilson MC et al. Internists' attitudes about clinical practice guidelines. *Ann Intern Med* 1994;120(11):956-963.

48. Hayward RS, Wilson MC, Tunis SR, Guyatt GH, Moore KA, Bass EB. Practice guidelines. What are internists looking for? *J Gen Intern Med* 1996;11(3):176-178.

49. Porta M. A Dictionary of Epidemiology. 5th ed. New York: Oxford University Press; 2008.

50. IOM (Institute of Medicine). Best care at lower cost: The path to continuously learning health care in America. Washington, DC: The National Academies Press, 2013

51. Veness M, Rikard-Bell G, Ward J. Views of Australian and New Zealand radiation oncologists and registrars about evidence-based medicine and their access to Internet based sources of evidence. *Australas Radiol* 2003;47(4):409-415.

52. National Health and Medical Research Council. NHMRC levels of evidence and grades for recommendations for guideline developers. Canberra:NHMRC, 2009 (Accessed 23-01-2017 at https://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/developers/nhmrc_levels_grades_evidence_120423.pdf).

53. OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence. 2011. Oxford: Oxford Centre for Evidence-Based Medicine (Accessed 10-07-2017 at http://www.cebm.net/ocebm-levels-of-evidence/).

54. Haynes RB. Of studies, syntheses, synopses, and systems: the "4S" evolution of services for finding current best evidence. *ACP J Club* 2001;134(2):A11-A13.

55. Haynes RB. Of studies, syntheses, synopses, summaries, and systems: the "5S" evolution of information services for evidence-based health care decisions. *ACP J Club* 2006;145(3):A8.

56. Dicenso A, Bayley L, Haynes RB. Accessing pre-appraised evidence: fine-tuning the 5S model into a 6S model. *Evid Based Nurs* 2009;12(4):99-101.

57. Alper BS, Haynes RB. EBHC pyramid 5.0 for accessing preappraised evidence and guidance. *Evid Based Med* 2016;21(4):123-125.

58. Perrier L, Persaud N, Ko A et al. Development of two shortened systematic review formats for clinicians. *Implement Sci* 2013;8:68.

59. Cochrane. The Cochrane Library. London: The Cochrane Collaboration (Accessed 15-8-2017 at http://www.cochranelibrary.com/).

60. Shah BR, Bhattacharyya O, Yu CH et al. Effect of an educational toolkit on quality of care: a pragmatic cluster randomized trial. *PLoS Med* 2014;11(2):e1001588.

61. Flodgren G, Conterno LO, Mayhew A, Omar O, Pereira CR, Shepperd S. Interventions to improve professional adherence to guidelines for prevention of device-related infections. *Cochrane Database Syst Rev* 2013;(3):CD006559.

62. Guyatt GH, Meade MO, Jaeschke RZ, Cook DJ, Haynes RB. Practitioners of evidence based care. Not all clinicians need to appraise evidence from scratch but all need some skills. *BMJ* 2000;320(7240):954-955.

63. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ* 1996;312(7023):71-72.

64. Bastian H, Glasziou P, Chalmers I. Seventy-five trials and eleven systematic reviews a day: how will we ever keep up? *PLoS Med* 2010;7(9):e1000326.

65. Stjernsward J. Decreased survival related to irradiation postoperatively in early operable breast cancer. *Lancet* 1974;2(7892):1285-1286.

66. Cochrane. Cochrane Vision, Mission and Principles. London: The Cochrane Collaboration (Accessed 1-8-2017 at www.cochrane.org/about-us/our-vision-mission-and-principles).

67. Cochrane. Cochrane database of systematic reviews. London: The Cochrane Collaboration (Accessed on 15-8-2017 at www.cochranelibrary.com/cochrane-database-of-systematic-reviews/).

68. Oliveri RS, Gluud C, Wille-Jorgensen PA. Hospital doctors' self-rated skills in and use of evidence-based medicine - a questionnaire survey. *J Eval Clin Pract* 2004;10(2):219-226.

69. Institute of Medicine (US) Committee on Standards for Developing Trustworthy Clinical Practice Guidelines. Clinical Practice Guidelines We Can Trust. Graham R, Mancher M, Miller Wolman D, et al, editors. Washington, DC: National Academies Press (US); 2011.

70. Woolf SH, Grol R, Hutchinson A, Eccles M, Grimshaw J. Clinical guidelines: potential benefits, limitations, and harms of clinical guidelines. *BMJ* 1999;318(7182):527-530.

71. National Institute for Health and Care Excellence. Hypertension in adults: diagnosis and management, Clinical guideline CG127. London: United Kingdom; 2011. (Accessed 20-12-2016 at https://www.nice.org.uk/guidance/cg127).

72. National Heart Foundation of Australia. Guideline for the diagnosis and management of hypertension in adults 2016. Canberra: National Heart Foundation of Australia; 2016 (Accessed 24-01-2017 at https://www.heartfoundation.org.au/for-professionals/clinical-information/hypertension).

73. Mancia G, Fagard R, Narkiewicz K et al. 2013 ESH/ESC guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Eur Heart J* 2013;34(28):2159-2219.

74. Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. A cooperative study. *JAMA* 1977;237(3):255-261.

75. James PA, Oparil S, Carter BL et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *JAMA* 2014;311(5):507-520.

76. Mozaffarian D, Benjamin EJ, Go AS et al. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. *Circulation* 2015;131(4):e29-322.

77. Grilli R, Lomas J. Evaluating the message: the relationship between compliance rate and the subject of a practice guideline. *Med Care* 1994;32(3):202-213.

78. Daucourt V, Saillour-Glenisson F, Michel P, Jutand MA, Abouelfath A. A multicenter cluster randomized controlled trial of strategies to improve thyroid function testing. *Med Care* 2003;41(3):432-441.

79. Avorn J, Soumerai SB. Improving drug-therapy decisions through educational outreach. A randomized controlled trial of academically based "detailing". *N Engl J Med* 1983;308(24):1457-1463.

80. Berner ES, Baker CS, Funkhouser E et al. Do local opinion leaders augment hospital quality improvement efforts? A randomized trial to promote adherence to unstable angina guidelines. *Med Care* 2003;41(3):420-431.

81. Lomas J, Enkin M, Anderson GM, Hannah WJ, Vayda E, Singer J. Opinion leaders vs. audit and feedback to implement practice guidelines. Delivery after previous cesarean section. *JAMA* 1991;265(17):2202-2207.

82. Indications for cesarean section: final statement of the panel of the National Consensus Conference on Aspects of Cesarean Birth. *CMAJ* 1986;134(12):1348-1352.

83. Hiss RG, Macdonald R, Davis WK. Identification of physician educational influentials (EI's) in small community hospitals. Proceedings of the Seventeenth Annual Conference on Research in Medical Education. Washington, DC; 1978: 283–288.

84. Soumerai SB, McLaughlin TJ, Gurwitz JH et al. Effect of local medical opinion leaders on quality of care for acute myocardial infarction: a randomized controlled trial. *JAMA* 1998;279(17):1358-1363.

85. Majumdar SR, Tsuyuki RT, McAlister FA. Impact of opinion leader-endorsed evidence summaries on the quality of prescribing for patients with cardiovascular disease: a randomized controlled trial. *Am Heart J* 2007;153(1):22-28.

86. Kiessling A, Henriksson P. Efficacy of case method learning in general practice for secondary prevention in patients with coronary artery disease: randomised controlled study. *BMJ* 2002;325(7369):877-880.

87. Perrier L, Kealey MR, Straus SE. An iterative evaluation of two shortened systematic review formats for clinicians: a focus group study. *J Am Med Inform Assoc* 2014;21(e2):e341-e346.

88. Perrier L, Kealey MR, Straus SE. A usability study of two formats of a shortened systematic review for clinicians. *BMJ Open* 2014;4(12):e005919.

89. Perrier L, Persaud N, Thorpe KE, Straus SE. Using a systematic review in clinical decision making: a pilot parallel, randomized controlled trial. *Implement Sci* 2015;10:118.

90. Van Zuuren EJ, Gupta AK, Gover MD, Graber M, Hollis S. Systematic review of rosacea treatments. *J Am Acad Dermatol* 2007;56(1):107-115.

91. Ely JW, Osheroff JA, Ebell MH et al. Obstacles to answering doctors' questions about patient care with evidence: qualitative study. *BMJ* 2002;324(7339):710.

92. National Health and Medical Research Council. National Statement on Ethical Conduct in Research Involving Humans (2007). Canberra: Commonwealth of Australia (Accessed 22-02-2017 at https://www.nhmrc.gov.au/guidelines-publications/e72).

93. Dillman DA. The Design and Administration of Mail Surveys. *Annual Review of Sociology* 1991;17:225-249.

94. Jordens CF, Hawe P, Irwig LM et al. Use of systematic reviews of randomised trials by Australian neonatologists and obstetricians. *Med J Aust* 1998;168(6):267-270.

95. Edwards PJ, Roberts I, Clarke MJ et al. Methods to increase response to postal and electronic questionnaires. Cochrane Database of Systematic Reviews 2009, Issue 3. Art. No.: MR000008. DOI: 10.1002/14651858.MR000008.pub4.

96. Fanning E. Formatting a paper-based survey questionnaire: Best practices. *Practical Assessment, Research & Evaluation* 2005;10(12):1-14.

97. Martin.S.W, Meek.A.H, Willenberg.P. Sampling Methods. Veterinary Epidemiology: Principles and Methods. Ames: Iowa State University Press; 1987:32-33.

98. Dillman D, Smyth J, Christian M. Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method. 4th ed. New Jersey: Wiley; 2014.

99. Norman G. Likert scales, levels of measurement and the "laws" of statistics. *Adv Health Sci Educ Theory Pract* 2010;15(5):625-632.

100. Kleinbaum D, Kupper L, Nizam A, Muller K. Selecting the Best Regression Equation. Applied Regression Analysis and Other Multivariable Methods. 4th ed. California: Thomson Brooks/Cole; 2008:383-419.

101. Razali NM, Wah YB. Power comparisons of Shapiro-Wilk, Komogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics* 2011;2:21-33.

102. Pencina MJ, D'Agostino RBSr, D'Agostino RBJr, Vasan RS. Evaluating the added predictive ability of a new marker: from area under the ROC curve to reclassification and beyond. *Statistics in Medicine* 2008;27:157-172.

103. Doig GS, Simpson F. Efficient literature searching: a core skill for the practice of evidence-based medicine. *Intensive Care Med* 2003;29(12):2119-2127.

104. Heighes PT, Doig GS. Intensive care specialists' knowledge, attitudes, and professional use of published research evidence: a mail-out questionnaire survey of appropriate use of research evidence in clinical practice. *J Crit Care 2014*;29(1):116-122.

105. Crippen D, Doig GS, Liolios A. Critical Care Medicine e-mail list (CCM-L): An on-line survey of a global resource pool. *Crit Care Med* 2003;31(2):S497.

106. Juniper EF, Guyatt GH, Willan A, Griffith LE. Determining a minimal important change in a disease-specific Quality of Life Questionnaire. *J Clin Epidemiol* 1994;47(1):81-87.

107. McColl E, Jacoby A, Thomas L et al. Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients. *Health Technol Assess* 2001;5(31):1-256.

108. Kelley K, Clark B, Brown V, Sitzia J. Good practice in the conduct and reporting of survey research. *Int J Qual Health Care* 2003;15(3):261-266.

109. Dillman DA. Mail and telephone surveys: the Total Design Method. New York: Wiley; 1978.

110. Sierles FS. How to do research with self-administered surveys. *Acad Psychiatry* 2003;27(2):104-113.

111. Thorpe C, Ryan B, McLean SL et al. How to obtain excellent response rates when surveying physicians. *Fam Pract* 2009;26(1):65-68.

112. Asch DA, Jedrziewski MK, Christakis NA. Response rates to mail surveys published in medical journals. *J Clin Epidemiol* 1997;50(10):1129-1136.

113. Field TS, Cadoret CA, Brown ML et al. Surveying physicians: do components of the "Total Design Approach" to optimizing survey response rates apply to physicians? *Med Care* 2002;40(7):596-605.

114. Young JM, Glasziou P, Ward JE. General practitioners' self ratings of skills in evidence based medicine: validation study. *BMJ* 2002;324(7343):950-951.

115. Al-Kubaisi NJ, Al-Dahnaim LA, Salama RE. Knowledge, attitudes and practices of primary health care physicians towards evidence-based medicine in Doha, Qatar. *East Mediterr Health J* 2010;16(11):1189-1197.

116. Ten Bruggencate MJ, Kremer LC, Caron HN, Knops AM, van Dalen EC. Pediatric oncologists and evidence-based medicine: a postal survey in The Netherlands. *Pediatr Blood Cancer* 2009;52(2):231-236.

117. Risahmawati RR, Emura SS, Nishi TT, Koizumi SS. Japanese Resident Physicians' Attitudes, knowledge, and Perceived Barriers on the Practice of Evidence Based Medicine: a Survey. *BMC Res Notes* 2011;4:374.

118. Rogers EM. Diffusion of Innovations. 5th ed. New York: Free Press; 2003.

119. Bellomo R, Warrillow SJ, Reade MC. Why we should be wary of single-center trials. *Crit Care Med* 2009;37(12):3114-3119.

120. Burns KE, Duffett M, Kho ME et al. A guide for the design and conduct of self-administered surveys of clinicians. *CMAJ* 2008;179(3):245-252.

121. Dillman DA, Smyth JD, Christian LM. Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method. 3rd ed. New Jersey: John Wiley Co.; 2009.

122. Seguin R, Godwin M, MacDonald S, McCall M. E-mail or snail mail? Randomized controlled trial on which works better for surveys. *Can Fam Physician* 2004;50:414-419.

123. Sebo P, Maisonneuve H, Cerutti B, Fournier JP, Senn N, Haller DM. Rates, Delays, and Completeness of General Practitioners' Responses to a Postal Versus Web-Based Survey: A Randomized Trial. *J Med Internet Res* 2017;19(3):e83.

124. Braithwaite D, Emery J, De LS, Sutton S. Using the Internet to conduct surveys of health professionals: a valid alternative? *Fam Pract* 2003;20(5):545-551.

125. Leece P, Bhandari M, Sprague S et al. Internet versus mailed questionnaires: a controlled comparison (2). *J Med Internet Res 2004*;6(4):e39.

126. Griffith LE, Cook DJ, Guyatt GH, Charles CA. Comparison of open and closed questionnaire formats in obtaining demographic information from Canadian general internists. *J Clin Epidemiol 1999*;52(10):997-1005.

127. VanGeest JB, Johnson TP, Welch VL. Methodologies for improving response rates in surveys of physicians: a systematic review. *Eval Health Prof* 2007;30(4):303-321.

128. Kellerman SE, Herold J. Physician response to surveys. A review of the literature. *Am J Prev Med* 2001;20(1):61-67.

129. Kolb DA. Experiential Learning: Experience as the Source of Learning and Development. 2nd ed. New Jersey: Pearson Education Inc.; 2015.

130. Meduri GU, Headley AS, Golden E et al. Effect of prolonged methylprednisolone therapy in unresolving acute respiratory distress syndrome: a randomized controlled trial. *JAMA* 1998;280(2):159-165.

131. Meduri GU, Golden E, Freire AX et al. Methylprednisolone infusion in early severe ARDS: results of a randomized controlled trial. *Chest* 2007;131(4):954-963.

132. Steinberg KP, Hudson LD, Goodman RB et al. Efficacy and safety of corticosteroids for persistent acute respiratory distress syndrome. *N Engl J Med* 2006;354(16):1671-1684.

133. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet* 2003;362(9391):1225-1230.

134. Perrier L, Mrklas K, Shepperd S, Dobbins M, McKibbon KA, Straus SE. Interventions encouraging the use of systematic reviews in clinical decision-making: a systematic review. *J Gen Intern Med* 2011;26(4):419-426.

135. Flodgren G, Parmelli E, Doumit G et al. Local opinion leaders: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews 2011, Issue 8. Art. No.: CD000125. DOI: 10.1002/14651858.CD000125.pub4.

136. Ivers N, Jamtvedt G, Flottorp S et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database of Systematic Reviews 2012, Issue 6. Art. No.: CD000259. DOI: 10.1002/14651858.CD000259.pub3..

137. Forsetlund L, Bjorndal A, Rashidian A et al. Continuing education meetings and workshops: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews 2009, Issue 2. Art. No.: CD003030. DOI: 10.1002/14651858.CD003030.pub2.

138. Giguere A, Legare F, Grimshaw J et al. Printed educational materials: effects on professional practice and healthcare outcomes. Cochrane Database of Systematic Reviews 2012, Issue 10. Art. No.: CD004398. DOI: 10.1002/14651858.CD004398.pub3.

APPENDICES

Appendix A: University of Sydney HREC approval letters

Appendix B: Cover letter and participant information for the survey titled: Use of published research in Intensive Care

Appendix C: Questionnaire tool used in the survey titled: Use of published research in Intensive Care

Appendix D: Cover letter and participant information for the survey titled: Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes.

Appendix E: Questionnaire tools used in the survey titled: Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes.

Appendix F: Author's final version of published Journal of Critical Care manuscript.

THE UNIVERSITY OF SYDNEY

RESEARCH INTEGRITY
Human Research Ethics Committee
Web: http://sydney.edu.au/ethics/
Email: ro.humanethics@sydney.edu.au

Address for all correspondence:
Level 6, Jane Foss Russell Building - G02
The University of Sydney
NSW 2006 AUSTRALIA

Ref: PB/PE

13 September 2010

Associate Professor Gordon Doig
Northern Clinical School
Level 6 Main Block RNSH
Pacific Highway
ST LEONARDS NSW 2065
Email: gdoig@med.usyd.edu.au

Dear Professor Doig

Thank you for your correspondence dated 30 August 2010 addressing comments made by the Human Research Ethics Committee (HREC). The Executive Committee of the HREC, at its meeting of **7 September 2010**, considered this information and approved the protocol entitled **"Intensive Care Specialists' knowledge, attitudes and professional use of published research evidence: A mail out questionnaire survey."**.

Details of the approval are as follows:

Protocol No.:	**13029**
Approval Period:	**September 2010 to September 2011**
Authorised Personnel:	**Associate Professor Gordon Doig**
	Ms Philippa Heighes

Documents approved:
Cover Letter and Participant Information Statement Version 1
Questionnaire

The HREC is a fully constituted Ethics Committee in accordance with the National Statement on Ethical Conduct in Research Involving Humans-March 2007 under Section 5.1.29.

The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans. N.B. A report on this research <u>must</u> be submitted every 12 months from the date of the approval, or on completion of the project, whichever occurs first. Failure to submit reports will result in the withdrawal of consent for the project to proceed. Your report will be due on **30 September 2011**, please put this in your diary.

<u>Chief Investigator / Supervisor's responsibilities to ensure that:</u>

1. All serious and unexpected adverse events should be reported to the HREC within 72 hours for clinical trials/interventional research.

2. All unforeseen events that might affect continued ethical conduct of the project should be reported to the HREC as soon as possible.

3. Any changes to the protocol must be approved by the HREC before the research project can proceed.

Human Ethics Secretariat:
Ms Portia Richmond   **T:** +61 2 8627 8171 **E:** portia.richmond@sydney.edu.au
Ms Patricia Engelmann **T:** +61 2 8627 8172 **E:** patricia.engelmann@sydney.edu.au
Ms Kala Retnam   **T:** +61 2 8627 8173 **E:** kala.retnam@sydney.edu.au

ABN 15 211 513 464
CRICOS 00026A

4. All research participants are to be provided with a Participant Information Statement and Consent Form, unless otherwise agreed by the Committee. The following statement must appear on the bottom of the Participant Information Statement: *Any person with concerns or complaints about the conduct of a research study can contact The Manager, Research Integrity (Human Ethics), University of Sydney on +61 2 8627 8176 (Telephone); + 61 2 8627 8177 (Facsimile) or ro.humanethics@sydney.edu.au (Email).*

5. Copies of all signed Consent Forms must be retained and made available to the HREC on request.

6. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

7. The HREC approval is valid for four (4) years from the Approval Period stated in this letter. Investigators are requested to submit a progress report annually.

8. A report and a copy of any published material should be provided at the completion of the Project.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

Associate Professor Philip Beale
Chair
Human Research Ethics Committee

Copy: Philippa Heighes   pheighes@med.usyd.edu.au

Research Integrity
Human Research Ethics Committee

Tuesday, 4 August 2015

Assoc Prof Gordon Doig
Northern Clinical School: Medicine; Sydney Medical School
Email: gordon.doig@sydney.edu.au

Dear Gordon

I am pleased to inform you that the University of Sydney Human Research Ethics Committee (HREC) has approved your project entitled "**Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes.**".

Details of the approval are as follows:

Project No.:   2015/634

Approval Date: 04th August 2015

First Annual Report Due: 04th August 2016

Authorised Personnel: **Doig Gordon; Doig Gordon; Heighes Philippa Tracy;**

Documents Approved:

DATE	TYPE	DOCUMENT NAME
10/07/2015	Questionnaires/Surveys	Questionnaire - Version B
10/07/2015	Questionnaires/Surveys	Questionnaire - Version A
28/07/2015	Participant Info Statement	Cover letter& Revised PIS tracked changes

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

Condition/s of Approval

- Continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans.

- Provision of an annual report on this research to the Human Research Ethics Committee from the approval date and at the completion of the study. Failure to submit reports will result in withdrawal of ethics approval for the project.

- All serious and unexpected adverse events should be reported to the HREC within 72 hours.

- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the HREC as soon as possible.

- Any changes to the project including changes to research personnel must be approved by the HREC before the research project can proceed.

- Note that for student research projects, a copy of this letter must be included in the candidate's thesis.

Chief Investigator / Supervisor's responsibilities:

1. You must retain copies of all signed Consent Forms (if applicable) and provide these to the HREC on request.

2. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

R. L. Shackel

Dr Rita Shackel
Chair
Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

THE UNIVERSITY OF
SYDNEY

Northern Clinical School
Intensive Care Research Unit
University of Sydney

COVER LETTER AND PARTICIPANT INFORMATION FOR THE SURVEY TITLED:
Use of published research evidence in Intensive Care

Thursday, 18 November 2010

Dear Fellow of the College of Intensive Care Medicine,

This survey has been mailed to you with the full support and cooperation of the **College of Intensive Care Medicine**. This survey seeks to gain insights into how and when Intensive Care Specialists use published research evidence to support clinical practice. It is being conducted by A/Prof Gordon Doig and Philippa Heighes from the Northern Clinical School Intensive Care Research Unit at the University of Sydney.

We appreciate that your time is valuable. It should only take 5 to 10 minutes to complete the questionnaire. We would be grateful for your completion of the questionnaire at your earliest convenience.

Your participation in this survey is completely voluntary and your responses will be anonymous and confidential. You are under no obligation to complete the questionnaire. Submission of a completed questionnaire will be taken as an indication of your consent to participate in the study. You can withdraw any time prior to submitting your completed questionnaire. Because there are no identifiable markings on the questionnaire, once you have submitted your completed questionnaire your responses will be anonymous and cannot be traced or withdrawn.

Postage-paid return envelopes have been marked with a unique identification code to enable the registration of responders. The return envelope will be separated from the anonymous questionnaire upon receipt. Data will be processed blinded to identity to maintain your anonymity. All source data will be stored for 7 years, as required by University of Sydney Ethics Committee policy. Only the named researchers will have access to participant-level information.

Aggregate level-summary information that cannot result in the identification of respondents, may be shared with the **College of Intensive Care Medicine** and will be published and presented at academic meetings. However aggregate level-summary information will be presented in such a way that individuals cannot be identified.

This study has been reviewed and approved by The University of Sydney Human Research Ethics Committee. The Human Research Ethics Committee has determined

that this study meets the ethical obligations required by law and University policies. If you have further questions or concerns regarding this study please contact the Investigators:

A/Prof Gordon S. Doig
Royal North Shore Hospital,
Intensive Care Unit,
St Leonards, NSW
Australia 2065

02 9926 8656
gdoig@med.usyd.edu.au

Philippa Heighes
Royal North Shore Hospital,
Intensive Care Unit,
St Leonards, NSW
Australia 2065

02 9926 8656
pheighes@med.usyd.edu.au

We would sincerely appreciate your completion and return of the attached questionnaire in the enclosed stamped, self-addressed envelope. Since the validity of the results depend on obtaining a high response rate, your participation is crucial to the success of this study.

We thank you in advance for your participation.

Yours Sincerely,

Gordon Doig

Philippa Heighes

Any persons with concerns or complaints about the conduct of this research project can contact:
The Manager, Human Ethics Administration, University of Sydney, NSW 2006
+61 2 8627 8176 (Telephone);
+61 2 8627 8177 (Facsimile) or
ro.humanethics@sydney.edu.au (Email)

Use of published research evidence in Intensive Care.

Please return completed questionnaire to Philippa Heighes
c/- ICU Office Level 6 RNSH Pacific Highway St Leonards 2065 NSW Australia

---

Please answer all of the following questions to the best of your ability:

Demographics:

1. **What year did you first become registered with the Joint Faculty Of Intensive Care Medicine (JFICM)/ College of Intensive Care Medicine (CICM)?**

   (please insert year here)

2. **Are you:** Female ☐   Male ☐

3. **What year were you born?**

   (please insert year here)

4. **Please indicate your level of training or qualification in research:** *(select **all** that apply)*

   a: Research fellowship ☐

   b: Formal research methodology course *(eg short course at university)* ☐

   d: Certificate, Diploma or Degree in research methodology

       (I) Graduate Certificate level ☐

       (II) Graduate Diploma level ☐

       (III) Masters level ☐

       (IV) PhD level ☐

   e: No formal research qualification ☐

5. **Please indicate your level of training in Evidence Based Medicine (EBM):** *(select **all** that apply)*

   a: Have attended an EBM course/workshop
   (eg offered at a hospital, a conference or by a for-profit organisation) ☐

   b: Have attended an EBM course/workshop offered by a University ☐

   c: Have attended an EBM course/workshop at McMaster University ☐

   d: No formal training in EBM ☐

Research Experience:

6. **Do you hold an academic appointment within a university?**   YES ☐   NO ☐

7. **Have you published any research papers as a named contributing or primary author?**   YES ☐   NO ☐

8. **Are you involved in the running of any funded clinical trials?**   YES ☐   NO ☐

9. **Have you ever consented a patient for a clinical trial?**   YES ☐   NO ☐

10. **Are you or have you been named as an investigator on an ethics submission for a funded clinical trial?**   YES ☐   NO ☐

Use of published research evidence in Intensive Care.
Please return completed questionnaire to Philippa Heighes
c/- ICU Office Level 6 RNSH Pacific Highway St Leonards 2065 NSW Australia

11. How many hours a week do you devote to your own continuing medical education?

(eg journal club, grand rounds, self study)

(please insert hours here)

12. How often do you use the Internet? *(select only **one**)*

a: Daily ☐   b: At least weekly ☐   c: Less than weekly ☐   d: Never ☐

13. For what purposes do you use a computer? *(select **all** that apply)*

a: For word processing ☐

b: For data analysis ☐

c: To search databases for published research papers ☐

d: Other ☐

Research Knowledge:

	Incorrect	Not sure	Correct

*(select only **one** for each statement)*

14. The CONSORT Statement is an international guidance document intended to improve the reporting of Randomised Controlled Trials (RCT). ☐ ☐ ☐

15. Allocation concealment refers to the act of masking which treatment a patient enrolled in a clinical trial is currently receiving from the treating clinician. ☐ ☐ ☐

16. The PRISMA Statement is an international guidance document intended to address the suboptimal reporting of systematic reviews and meta-analyses of RCTs. ☐ ☐ ☐

17. Conventionally, results in a clinical trial are considered to be statistically significant (ie unlikely to have arisen by chance) if the p value is less than 0.05 ($p < 0.05$). ☐ ☐ ☐

18. In a meta-analysis, the I^2 metric is a measure of heterogeneity that is dependant on the number of patients included in a trial. ☐ ☐ ☐

19. The forest plot is a graph used in a meta-analysis to detect publication bias in which the estimate of risk is plotted against sample size. ☐ ☐ ☐

Use of published research evidence in Intensive Care.

Research attitudes:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
*(select only **one** for each statement)*					
20. My feelings towards EBM are positive.	☐	☐	☐	☐	☐
21. My colleagues' feelings towards EBM are positive.	☐	☐	☐	☐	☐
22. My feelings towards using the results of an RCT to guide my clinical practice are positive .	☐	☐	☐	☐	☐
23. My feelings towards using the results of a systematic review / meta-analysis to guide my clinical practice are positive.	☐	☐	☐	☐	☐
24. Time limitations are a factor that restrict the incorporation of EBM into my clinical practice in Intensive Care.	☐	☐	☐	☐	☐
25. The use of published research evidence has not made a difference to my clinical practice.	☐	☐	☐	☐	☐

Research use:

	Never	Rarely Once or twice a year	Sometimes Every month or so	Often Every week or so	Very often Every day or so
*(select only **one** for each statement)*					
26. How often do you use the concepts of EBM in your clinical practice?	☐	☐	☐	☐	☐
27. How often do you read the following?					
a Published RCT's	☐	☐	☐	☐	☐
b Information obtained from The Cochrane Library	☐	☐	☐	☐	☐
c Textbooks	☐	☐	☐	☐	☐
d Published evidence based guidelines	☐	☐	☐	☐	☐
e Published meta-analyses	☐	☐	☐	☐	☐

Use of published research evidence in Intensive Care.

	Never	**Rarely** Once or twice a year	**Sometimes** Every month or so	**Often** Every week or so	**Very often** Every day or so

*(select only **one** for each statement)*

28. **How often do you use the following information sources to guide decisions in your clinical practice?**

		Never	**Rarely**	**Sometimes**	**Often**	**Very often**
a	Information provided in evidence summary journals (Intensive Care Monitor etc).	☐	☐	☐	☐	☐
b	Advice given to me by a colleague.	☐	☐	☐	☐	☐
c	Information I have read in a textbook.	☐	☐	☐	☐	☐
d	The results of a Cochrane review.	☐	☐	☐	☐	☐
e	The results of an RCT.	☐	☐	☐	☐	☐
f	Conference presentations.	☐	☐	☐	☐	☐
g	Published evidence based guidelines.	☐	☐	☐	☐	☐
h	Information I found through a Google search.	☐	☐	☐	☐	☐
i	The results of a meta-analysis.	☐	☐	☐	☐	☐

	Never	**Rarely** Once or twice a year	**Sometimes** Every month or so	**Often** Every week or so	**Very often** Every day or so

*(select only **one** for each statement)*

29. **How often do you use published research evidence in the following situations:**

		Never	**Rarely**	**Sometimes**	**Often**	**Very often**
a	Preparing a teaching session for trainees.	☐	☐	☐	☐	☐
b	Making individual patient care decisions.	☐	☐	☐	☐	☐
c	Developing guidelines or protocols.	☐	☐	☐	☐	☐
d	Settling a clinical dispute regarding patient management.	☐	☐	☐	☐	☐
e	Reviewing management of a past patient (eg M&Ms).	☐	☐	☐	☐	☐
f	Improving my knowledge.	☐	☐	☐	☐	☐
g	Preparing a presentation for colleagues.	☐	☐	☐	☐	☐
h	Preparing to provide information to a patient or next of kin.	☐	☐	☐	☐	☐

Use of published research evidence in Intensive Care.
Please return completed questionnaire to Philippa Heighes
c/- ICU Office Level 6 RNSH Pacific Highway St Leonards 2065 NSW Australia

		Never helps	Rarely helps	Sometimes	Often helps	Very often helps

*(select only **one** for each statement)*

30. How often are the following factors likely to *help* your decision to use the results of published research evidence to change practice:

		Never helps	Rarely helps	Sometimes	Often helps	Very often helps
a	The project was conducted in my own health care system.	☐	☐	☐	☐	☐
b	The project included a lot of patients.	☐	☐	☐	☐	☐
c	The paper was clearly written *(ie concise, coherent, to the point, logical).*	☐	☐	☐	☐	☐
e	The paper fully explored all possible benefits *and* harms.	☐	☐	☐	☐	☐
f	The project was methodologically sound, with no major flaws.	☐	☐	☐	☐	☐
g	Other Intensivists have changed practice based on this paper.	☐	☐	☐	☐	☐
h	The results will reduce costs but patient outcomes will not be compromised.	☐	☐	☐	☐	☐
i	The CONSORT or QUOROM statements were followed.	☐	☐	☐	☐	☐
j	I have seen the author present the findings of the project at a conference.	☐	☐	☐	☐	☐
k	I understand the pathophysiological rationale of the intervention.	☐	☐	☐	☐	☐
l	The results have clear benefit to my patients.	☐	☐	☐	☐	☐
m	The intervention is described in enough detail so that I could implement it in my clinical practice.	☐	☐	☐	☐	☐
n	The project involved multiple study centres.	☐	☐	☐	☐	☐
o	The paper was written by a recognised expert in the field.	☐	☐	☐	☐	☐
p	The paper is the second publication on this topic to demonstrate a significant benefit to patients.	☐	☐	☐	☐	☐
q	The paper presents a full economic analysis.	☐	☐	☐	☐	☐

Use of published research evidence in Intensive Care.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

*(select only **one** for each statement)*

31. The following factors *inhibit* my use of published research evidence in clinical practice:

a	I have difficulty finding the time to read.	☐	☐	☐	☐	☐
b	I have difficulties using MEDLINE.	☐	☐	☐	☐	☐
c	I can find papers using MEDLINE, but it is difficult to find *key* papers that are good enough to guide my practice.	☐	☐	☐	☐	☐
d	I have difficulties critically appraising papers.	☐	☐	☐	☐	☐
e	I have difficulties convincing my hospital to stock new drugs.	☐	☐	☐	☐	☐
f	I believe there is a lack of good evidence providing meaningful answers to my clinical problems.	☐	☐	☐	☐	☐
g	My colleagues do not support me when I am the first to change my own practice using new research evidence.	☐	☐	☐	☐	☐
h	I have insufficient authority to introduce some new practices into my hospital.	☐	☐	☐	☐	☐
i	Appraising published research papers is not part of my role.	☐	☐	☐	☐	☐
j	I do not have enough training in EBM.	☐	☐	☐	☐	☐
k	Individual patient variation is not accounted for in the results of published research.	☐	☐	☐	☐	☐
l	I do not trust observational studies enough to use them to guide my practice.	☐	☐	☐	☐	☐
m	Studies conducted in Europe and the USA do not apply to my patients.	☐	☐	☐	☐	☐

You have now reached the end of the questionnaire.
Thank you for taking the time to participate in our study.
Please return the questionnaire in the enclosed return envelope at your convenience.

THE UNIVERSITY OF
SYDNEY

Northern Clinical School
Intensive Care Research Unit
University of Sydney

COVER LETTER AND PARTICIPANT INFORMATION FOR THE SURVEY TITLED:

Facilitating practice change using an evidence summary tool: A survey of clinicians attitudes.

Thursday, 23 July 2015

Dear Member of the CCM-L Mailing list,

We are conducting a study to gain insights into the attitudes of Intensive Care Clinicians towards the use of Evidence Summary Tools to support clinical practice. With the support of Prof David Crippen, the convenor of the Critical Care Mailing List (CCM-L), we would like to invite you, as a subscribing member of CCM-L, to participate in this study. The study is being conducted by A/Prof. Gordon Doig and Philippa Heighes from the Northern Clinical School Intensive Care Research Unit at the University of Sydney, Australia.

Since the validity of the results depends on obtaining a high response rate, your participation is crucial to the success of this study. We therefore thank you in advance for your important contribution to our study. If you would like to participate in this study, we would appreciate you *responding via email* to pheighes@med.usyd.edu.au *to indicate your interest* at your earliest convenience.

On receipt of your email, we will send you a survey package containing one of two possible evidence summary tools selected by a random number generator, and a self-administered anonymous questionnaire. We appreciate that your time is valuable, and as such, it should only take 10 to 15 minutes to complete the questionnaire.

Your participation in this study is completely voluntary, you are under no obligation to complete the questionnaire and can withdraw any time prior to submitting your completed questionnaire with no consequences. Submission of a completed questionnaire will be taken to indicate your consent to participate in the study. Because there are no identifiable markings on the questionnaire, once you have submitted your completed questionnaire your responses will remain anonymous and cannot be withdrawn.

An anonymous drop box has been created at *https://research.evidencebased.net/dropbox* to enable you to easily return the completed questionnaire. Simply visit the web address provided and follow the links to upload your questionnaire. Your responses will be anonymous and

confidential, with data processed in de-identified form. All source data will be stored securely for 5 years, as required by University of Sydney Ethics Committee policy.

Anonymous aggregate level-summary information that cannot result in the identification of respondents may be shared with the **Critical Care Mailing List (CCM-L),** will be published and presented at academic meetings, and will be included in the PhD theses for Philippa Heighes.

This study has been reviewed and approved by the Human Research Ethics Committee (HREC) of the University of Sydney (protocol project number 2015/634) who have determined that the study meets the ethical obligations required by law and University policies. If you have further questions or would like to know more at any stage during the study please contact the Investigators:

A/Prof Gordon S. Doig
c/- Royal North Shore Hospital,
Intensive Care Unit,
St Leonards, NSW
Australia 2065

02 9463 2633
gdoig@med.usyd.edu.au

Philippa Heighes
c/- Royal North Shore Hospital,
Intensive Care Unit,
St Leonards, NSW
Australia 2065

02 9463 2633
pheighes@med.usyd.edu.au

Thank you in advance for taking the time to participate and for your important contribution to our study.

Yours Sincerely,

Gordon Doig

Philippa Heighes

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:
- **Telephone:** +61 2 8627 8176
- **Email:** ro.humanethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

Use of an Evidence Summary Tool in Intensive Care.
Return to: https://research.evidencebased.net/dropbox
OR print and mail to Philippa Heighes
c/- ICU Office Level 6 RNSH, Pacific Highway
St Leonards 2065 NSW Australia

THE UNIVERSITY OF
SYDNEY

SECTION 1 - DEMOGRAPHICS AND RESEARCH USE

General Instructions: Please answer all questions to the best of your ability in the order that they appear. Directions for completing individual questions are given throughout the questionnaire where necessary. When you have completed the questionnaire please save and return at your earliest convenience.

DEMOGRAPHICS:

1. **Are you:** Male ☐ Female ☐

    (select appropriate box)

2. **What is your current age?** ☐

    (please insert age here)

3. **What country do you live in?** ☐

    (please insert country here)

4. **What year did you first start working in Intensive Care?** ☐

    (please insert year here)

5. **Do you currently hold an academic appointment within a university?** Yes ☐ No ☐

    (select appropriate box)

6. **How many hours a week are you able to devote to your own continuing medical education?** ☐

    (eg journal club, grand rounds, self study)   *(please insert hours here)*

Continues next page.......

7. What is your current position? Please select the category that most accurately describes your daily role: *(select **only one**)*

a: Part time in Intensive Care, primary speciality in other field

b: Full time Intensive Care Specialist

c: ICU trainee

d: Nurse

e: Dietician

f: Physiotherapist

g: Occupational therapist

h: Respiratory therapist

i: Pharmacist

j: Other

8. Please indicate your level of training or qualification in research: *(select **all** that apply)*

a: Research fellowship

b: Formal research methodology course *(eg short course at university)*

c: Certificate, Diploma or Degree in research methodology

(I) Graduate Certificate level

(II) Graduate Diploma level

(III) Masters level

(IV) PhD level

d: No formal research qualification

9. Please indicate your level of training in Evidence Based Medicine (EBM):

*(select **all** that apply)*

a: Have attended a short EBM course/workshop
(eg offered at a hospital, a conference or by a for-profit organisation)

b: Have attended an EBM course/workshop at McMaster University

c: Have attended an EBM course/workshop at another University

d: No formal training in EBM

Continues next page.......

RESEARCH USE:

	Never	**Rarely** Once or twice a year	**Sometimes** Every month or so	**Often** Every week or so	**Very often** Every day or so

*(select only **one** for each statement)*

10. How often do you use the concepts of EBM in your clinical practice?

11. How often do you read the following?

  a Published Randomised Controlled Trials (RCTs)

  b Information obtained from The Cochrane Library

  c Textbooks

  d Published evidence based guidelines

  e Published systematic reviews/ meta-analyses

  f Evidence summaries

12. How often do you use the following information sources to guide decisions in your clinical practice?

  a Information provided in evidence summary journals (eg Intensive Care Monitor etc)

  b Advice given to me by a colleague

  c Information I have read in a textbook

  d The results of a Cochrane review

  e The results of an RCT

  f Published evidence based guidelines

  g Information I found through a Google search.

  h The results of a systematic review/ meta-analysis.

Continues next page.......

SECTION TWO – CLINICAL SCENARIO

General Instructions: Please carefully read the clinical scenario presented to you following these instructions. When you have finished reading the scenario you will be asked some questions regarding the ongoing management of the patient presented.

Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status.

Please indicate your level of agreement with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

*(select only **one** for each statement)*

13. I believe that this patient may benefit from High Frequency Oscillatory Ventilation

14. I believe that this patient may benefit from Prone Positioning

15. I believe that this patient may benefit from Non-Invasive Bi-Level positive airway pressure (BiPAP) ventilation

16. I believe that this patient may benefit from the use of corticosteroids

17. I believe that this patient may benefit from the use of increased levels of PEEP

18. I believe that this patient may benefit from Extra-Corporeal Membrane Oxygenation (ECMO)

SECTION THREE – EVIDENCE SUMMARY TOOL

*On the **next page** you will find an Evidence Summary Tool that presents recent evidence from published literature regarding the management of patients with severe ARDS. Please carefully read the Tool and consider the evidence presented before moving onto Section Four*

Continues next page.......

Early Prone Positioning Saves Lives in Severe Acute Respiratory Distress Syndrome

Philippa Heighes, Research Fellow (email: pheighes@med.usyd.edu.au)
Northern Clinical School Intensive Care Research Unit, University of Sydney Australia

Prone Positioning in ARDS saves lives

To save 1 life you need to prone 6 patients with severe ARDS on low-tidal volume ventilation.

This is supported by a significant mortality reduction in a well conducted RCT analysing 466 patients from 27-hospitals and 5 smaller RCTs enrolling an additional 542 patients.

Other patient benefits

For every 15 patients proned, 1 cardiac arrest is prevented.[1]

For every 7 patients proned, 1 additional patient is successfully extubated before Day 90. [1]

Potential harms

For every 25 patients proned, 1 transient endotracheal tube obstruction occurs.[2]

For every 77 patients proned, 1 thoracotomy tube is dislodged.[2]

For every 10 patients proned, 1 additional pressure ulcer occurs.[2]

There is no documented increase in additional accidental extubations.[1,2,3]

Identifying patients that will benefit from prone positioning

1) Identify *severe ARDS* patients *early*
   Intubated and ventilated < 36 hours AND PaO_2:FiO_2 ratio < 150mmHg.
2) Implement *low-tidal volume* ventilation for a period of 12 to 24 hours
   Ensure PEEP is at least $5cmH_2O$ and $FiO_2 \geq 0.6$.
3) If PaO2:FiO2 ratio remains < 150 mmHg, consider proning.

Implementing prone positioning in suitable patients

1) Maintain prone position for *at least* 16 consecutive hours.
2) Following return to supine position reassess PaO_2:FiO_2 ratio and continue to use prone positioning each day if PaO_2:FiO_2 ratio < 150mmHg.
3) If PaO_2:FiO_2 ratio $\geq$ 150mmHg and PEEP $\leq$ $10cmH_2O$ and $FiO_2 \leq 0.6$ cease prone positioning.

Useful educational resources regarding prone positioning

The successful management of the patient in prone position relies on the skill of the staff performing the procedure. Adequate training and experience of staff is key to maintaining patient safety and minimising potential harms.

Guidelines for standardising prone positioning and a useful 5 minute training video demonstrating prone positioning procedure available at http://www.nejm.org/

A complete list of eligibility criteria and contraindications can be found at
http://www.nejm.org/suppl

Physiological rationale of why prone position is beneficial

Prone positioning leads to more equal ventilation perfusion match; more uniform alveolar recruitment and expansion; and more even distribution of pleural pressure within the lungs

Brief summary of Evidence Reviewed

466 patient RCT[1] published in NEJM in 2013. There were no major flaws in this paper.

Five additional RCTs enrolled 22 - 344 patients each. Four of these additional RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation.[2,3]

References – click journal title for PubMed link

1. Guerin C et al. *Prone positioning in severe acute respiratory distress syndrome.* **NEJM** 2013;368:2159-68.
2. Sud S et al. *Effect of prone positioning during mechanical ventilation on mortality among patients with acute respiratory distress syndrome: a systematic review and meta-analysis.* **CMAJ** 2014; 186:E381-E390.
3. Beitler J et al. *Prone positioning reduces mortality from acute respiratory distress syndrome in the low tidal volume era: a meta analysis.* **ICM** 2014; 40:332-341.

SECTION FOUR – CLINICAL SCENARIO

Now that you have read through the Evidence Summary Tool, please once again consider the clinical scenario presented earlier and answer the questions that follow:

Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status.

Please indicate your level of agreement with the following statements:

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

*(select only **one** for each statement)*

19.	**I believe that this patient may benefit from High Frequency Oscillatory Ventilation**
20.	**I believe that this patient may benefit from Prone Positioning**
21.	**I believe that this patient may benefit from Non-Invasive Bi-Level positive airway pressure (BiPAP) ventilation**
22.	**I believe that this patient may benefit from the use of corticosteroids**
23.	**I believe that this patient may benefit from the use of increased levels of PEEP**
24.	**I believe that this patient may benefit from Extra-Corporeal Membrane Oxygenation (ECMO)**
25.	**My feelings towards using the results of an RCT to guide my clinical practice are positive.**
26.	**My feelings towards using the results of a systematic review/ meta-analysis to guide my clinical practice are positive.**

You have now reached the end of the questionnaire.
Thank you for taking the time to participate in our study.

Please save and return the questionnaire at your earliest convenience to **Philippa Heighes**
Upload to - *https://research.evidencebased.net/dropbox*
or mail *c/- ICU Office Level 6 RNSH, Pacific Highway, St Leonards 2065 NSW Australia*

Use of an Evidence Summary Tool in Intensive Care.

Return to: https://research.evidencebased.net/dropbox
OR print and mail to Philippa Heighes
c/- ICU Office Level 6 RNSH, Pacific Highway
St Leonards 2065 NSW Australia

SECTION 1 - DEMOGRAPHICS AND RESEARCH USE

General Instructions: Please answer all questions to the best of your ability in the order that they appear. Directions for completing individual questions are given throughout the questionnaire where necessary. When you have completed the questionnaire please save and return at your earliest convenience.

DEMOGRAPHICS:

1. **Are you:**

   Male ☐   Female ☐

   (select appropriate box)

2. **What is your current age?**

   (please insert age here)

3. **What country do you live in?**

   (please insert country here)

4. **What year did you first start working in Intensive Care?**

   (please insert year here)

5. **Do you currently hold an academic appointment within a university?**

   Yes ☐   No ☐

   (select appropriate box)

6. **How many hours a week are you able to devote to your own continuing medical education?**

   (eg journal club, grand rounds, self study)   *(please insert hours here)*

Continues next page.......

7. What is your current position? Please select the category that most accurately describes your daily role: *(select **only one**)*

a: Part time in Intensive Care, primary speciality in other field

b: Full time Intensive Care Specialist

c: ICU trainee

d: Nurse

e: Dietician

f: Physiotherapist

g: Occupational therapist

h: Respiratory therapist

i: Pharmacist

j: Other

8. Please indicate your level of training or qualification in research: *(select **all** that apply)*

a: Research fellowship

b: Formal research methodology course *(eg short course at university)*

c: Certificate, Diploma or Degree in research methodology

(I) Graduate Certificate level

(II) Graduate Diploma level

(III) Masters level

(IV) PhD level

d: No formal research qualification

9. Please indicate your level of training in Evidence Based Medicine (EBM):

*(select **all** that apply)*

a: Have attended a short EBM course/workshop
(eg offered at a hospital, a conference or by a for-profit organisation)

b: Have attended an EBM course/workshop at McMaster University

c: Have attended an EBM course/workshop at another University

d: No formal training in EBM

Continues next page.......

	Never	Rarely Once or twice a year	Sometimes Every month or so	Often Every week or so	Very often Every day or so

RESEARCH USE:

*(select only **one** for each statement)*

10. How often do you use the concepts of EBM in your clinical practice?

11. How often do you read the following?

   a Published Randomised Controlled Trials (RCTs)

   b Information obtained from The Cochrane Library

   c Textbooks

   d Published evidence based guidelines

   e Published systematic reviews/ meta-analyses

   f Evidence summaries

12. How often do you use the following information sources to guide decisions in your clinical practice?

   a Information provided in evidence summary journals
     (eg Intensive Care Monitor etc)

   b Advice given to me by a colleague

   c Information I have read in a textbook

   d The results of a Cochrane review

   e The results of an RCT

   f Published evidence based guidelines

   g Information I found through a Google search.

   h The results of a systematic review/ meta-analysis.

Continues next page.......

SECTION TWO – CLINICAL SCENARIO

General Instructions: Please carefully read the clinical scenario presented to you following these instructions. When you have finished reading the scenario you will be asked some questions regarding the ongoing management of the patient presented.

Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status.

Please indicate your level of agreement with the following statements:

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |

*(select only **one** for each statement)*

13. **I believe that this patient may benefit from High Frequency Oscillatory Ventilation**

14. **I believe that this patient may benefit from Prone Positioning**

15. **I believe that this patient may benefit from Non-Invasive Bi-Level positive airway pressure (BiPAP) ventilation**

16. **I believe that this patient may benefit from the use of corticosteroids**

17. **I believe that this patient may benefit from the use of increased levels of PEEP**

18. **I believe that this patient may benefit from Extra-Corporeal Membrane Oxygenation (ECMO)**

SECTION THREE – EVIDENCE SUMMARY TOOL

*On the **next page** you will find an Evidence Summary Tool that presents recent evidence from published literature regarding the management of patients with severe ARDS. Please carefully read the Tool and consider the evidence presented before moving onto Section Four*
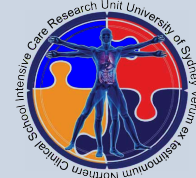
Continues next page.......

Early Prone Positioning Saves Lives in Severe Acute Respiratory Distress Syndrome

Philippa Heighes, Research Fellow (email: pheighes@med.usyd.edu.au)
Northern Clinical School Intensive Care Research Unit, University of Sydney Australia

Prone Positioning in ARDS saves lives

To save 1 life you need to prone 6 patients with severe ARDS on low-tidal volume ventilation.

This is supported by a significant mortality reduction in two well conducted meta-analyses including 6 RCTs enrolling a total of 1,016 patients.

Other patient benefits

For every 15 patients proned, 1 cardiac arrest is prevented.[1]

For every 7 patients proned, 1 additional patient is successfully extubated before Day 90. [1]

Potential harms

For every 25 patients proned, 1 transient endotracheal tube obstruction occurs.[2]

For every 77 patients proned, 1 thoracotomy tube is dislodged.[2]

For every 10 patients proned, 1 additional pressure ulcer occurs.[2]

There is no documented increase in additional accidental extubations.[1,2,3]

Identifying patients that will benefit from prone positioning

1) Identify *severe ARDS* patients *early*
   Intubated and ventilated < 36 hours AND $PaO_2:FiO_2$ ratio < 150mmHg.
2) Implement *low-tidal volume* ventilation for a period of 12 to 24 hours
   Ensure PEEP is at least $5cmH_2O$ and $FiO_2 \geq 0.6$.
3) If PaO2:FiO2 ratio remains < 150 mmHg, consider proning.

Implementing prone positioning in suitable patients

1) Maintain prone position for *at least* 16 consecutive hours.
2) Following return to supine position reassess $PaO_2:FiO_2$ ratio and continue to use prone positioning each day if $PaO_2:FiO_2$ ratio < 150mmHg.
3) If $PaO_2:FiO_2$ ratio $\geq$ 150mmHg and PEEP $\leq 10cmH_2O$ and $FiO_2 \leq 0.6$ cease prone positioning.

Useful educational resources regarding prone positioning

The successful management of the patient in prone position relies on the skill of the staff performing the procedure. Adequate training and experience of staff is key to maintaining patient safety and minimising potential harms.

Guidelines for standardising prone positioning and a useful 5 minute training video demonstrating prone positioning procedure available at http://www.nejm.org/

A complete list of eligibility criteria and contraindications can be found at
http://www.nejm.org/suppl

Physiological rationale of why prone position is beneficial

Prone positioning leads to more equal ventilation perfusion match; more uniform alveolar recruitment and expansion; and more even distribution of pleural pressure within the lungs

Brief summary of Evidence Reviewed

Meta-analyses published in CMAJ[2] and ICM[3] in 2014. The six included RCTs enrolled 22 - 474 patients each. Five RCTs were free from major flaws, whilst 1 RCT had a high risk of bias due to failure to conceal allocation. One meta-analysis included all six trials[2] whilst the second focused on adult patients, and included the four trials that were free from major flaws.[3]

References– click journal title for PubMed link

1. Guerin C et al. *Prone positioning in severe acute respiratory distress syndrome.* **NEJM** 2013;368:2159-68.
2. Sud S et al. *Effect of prone positioning during mechanical ventilation on mortality among patients with acute respiratory distress syndrome: a systematic review and meta-analysis.* **CMAJ** 2014; 186:E381-E390.
3. Beitler J et al. *Prone positioning reduces mortality from acute respiratory distress syndrome in the low tidal volume era: a meta analysis.* **ICM** 2014; 40:332-341.

SECTION FOUR – CLINICAL SCENARIO

Now that you have read through the Evidence Summary Tool, please once again consider the clinical scenario presented earlier and answer the questions that follow:

Mr Mathews, a 68 year old male who weighs 89kg (196lb) and is 178cm (5'10") in height was admitted to your ICU 30 hours ago with community acquired pneumonia and sepsis. Chest x-ray showed diffuse bilateral opacities and a BiPAP trial for worsening respiratory function failed. He was intubated 26 hours ago and commenced on mechanical ventilation for the management of severe ARDS.

This morning, Tidal Volume is 450mls, PEEP is set at 14cmH$_2$O with an FiO$_2$ of 0.8 and a PaO$_2$:FiO$_2$ ratio of 73. You have attempted multiple lung recruitment manoeuvres with no visible improvement and remain concerned with his respiratory status.

Please indicate your level of agreement with the following statements:

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

*(select only **one** for each statement)*

19.	I believe that this patient may benefit from High Frequency Oscillatory Ventilation
20.	I believe that this patient may benefit from Prone Positioning
21.	I believe that this patient may benefit from Non-Invasive Bi-Level positive airway pressure (BiPAP) ventilation
22.	I believe that this patient may benefit from the use of corticosteroids
23.	I believe that this patient may benefit from the use of increased levels of PEEP
24.	I believe that this patient may benefit from Extra-Corporeal Membrane Oxygenation (ECMO)
25.	My feelings towards using the results of an RCT to guide my clinical practice are positive.
26.	My feelings towards using the results of a systematic review/ meta-analysis to guide my clinical practice are positive.

You have now reached the end of the questionnaire.
Thank you for taking the time to participate in our study.

Please save and return the questionnaire at your earliest convenience to **Philippa Heighes**
Upload to - *https://research.evidencebased.net/dropbox*
or mail *c/- ICU Office Level 6 RNSH, Pacific Highway, St Leonards 2065 NSW Australia*

APPENDIX F

Intensive Care Specialists' knowledge, attitudes and professional use of published research evidence: A mail out questionnaire survey of appropriate use of research evidence in clinical practice.

Philippa T Heighes

Gordon S Doig

Northern Clinical School Intensive Care Research Unit, University of Sydney, Sydney, Australia.

All correspondence should be addressed to:

Dr. Gordon S. Doig,

Associate Professor in Intensive Care and Head, Northern Clinical School Intensive Care Research Unit, University of Sydney

c/- Royal North Shore Hospital

Intensive Care Unit

Pacific Highway

St Leonards NSW 2065

AUSTRALIA

(Tel.) +612 9463 2633

(Fax) +612 9463 2057

gdoig@med.usyd.edu.au

We certify that there is no conflict of interest with any financial organisation regarding the material presented in this paper.

Abstract – 196 words, Total manuscript length – 3907 words

Abstract:

Purpose

This survey investigates the knowledge, attitudes and use of published research in clinical practice by Intensive Care Specialists.

Materials and Methods

A mail out questionnaire was sent to randomly selected Intensive Care Specialists registered with the Australian and New Zealand College of Intensive Care Medicine.

Results

The response rate was 55.9% (133/238). The average score for research knowledge was 2.9 out of 6. 65.4% (85/130) of respondents reported positive feelings towards using published research evidence in clinical practice with 96.6% (126/130) reporting use of the concepts of evidence-based medicine *at least sometimes.* Randomised trials were rated as the *most frequently read* evidence (rank score 3.7 out of 5) with 'Information obtained from the Cochrane Library' the *least frequently read* (rank score 2.8 out of 5). The *most inhibiting barrier* to use of published research evidence in practice was *'a lack of good evidence providing meaningful answers to clinical problems'* (rank score 3.5 out of 5). 67.7% (88/130) of respondents *appropriately* used published research evidence in clinical practice.

Conclusions

Respondents reported generally *positive attitudes* towards using published research evidence, in clinical practice, however, room for improvement in technical knowledge relating to published research evidence was noted.

(1) Introduction:

Since its inception in the early 90's, evidence-based medicine (EBM) has been widely promoted in the medical literature as a paradigm in which patient care decisions are based on the best available evidence in conjunction with clinical expertise and patient preference.[1] Despite this, studies suggest that 30-40% of patients do not receive care in line with the best available evidence.[2,3] The provision of medical care unsupported by current evidence is costly, with estimates that the US health care system wastes in excess of $200 billion per year on unnecessary medical care.[4] Situations where evidence-practice gaps have been identified highlight the importance of ensuring appropriate uptake of research evidence as it may ultimately help save lives and reduce costs associated with inappropriate care.[5,6]

Implementing a change in clinical practice based upon the results of published research evidence is a multifaceted and complex process. The results of published research evidence, pathophysiologic understanding, clinical experience and patient preferences all influence the decision making of clinicians.[7] The 'Theory of Planned Behaviour' particularly highlights *attitudes* as one of three major characteristics that determine the likelihood of someone changing their behaviour, with positive attitudes being found in those more likely to adopt change early on.[8]

In line with change management theories, there is an emerging interest in the literature in the exploration of *attitudes* towards published research evidence and its use in clinical practice. Surveys conducted in groups of general practitioners, oncologists and urologists showed generally positive *attitudes* towards research evidence and its use in clinical practice,[9-12] however, a methodologically rigorous study of 933 Italian physicians revealed that whilst the physicians generally had positive attitudes towards research evidence, according to self-reported measures of use, 68% of respondents failed to *appropriately use* published research evidence to guide their clinical practice.[13] It has been estimated that whilst the Intensive Care Unit (ICU) accounts for less than 10% of hospital beds, it is a particularly resource heavy area, consuming 22% of total hospital costs in the United States.[14] As such, the application of the results of published research evidence in the ICU may be especially important in regards to saving lives and reducing costs, however we were unable to identify any publications addressing this question.

Therefore, the aim of this study was to conduct a methodologically rigorous survey to identify the attitudes, knowledge, and appropriate use of published research evidence in clinical practice by Intensive Care Specialists in Australia and New Zealand.

(2) Methods:

Approval to conduct the study was obtained from the University of Sydney Human Research Ethics Committee (Protocol number 13029; September 2010).

Study design

In order to evaluate the knowledge, attitudes and use of published research evidence in clinical practice a self-administered mail out survey of randomly selected Intensive Care Specialists was conducted, with repeat mail outs to non-responders and anonymous responses.[15]

Sampling frame

All qualified Australian and New Zealand Intensive Care Specialists registered with the College of Intensive Care Medicine (CICM) (current January 2011) were eligible for participation in the survey. The CICM is the regulatory body for Intensive Care Medicine specialist training and education in Australia and New Zealand, providing a six-year specialist preparation programme to trainees, and continuing medical education, professional development and support to fellows.

Sample size

An Italian survey of physicians' knowledge, attitudes and professional use of randomised controlled trials and meta-analyses found that, according to self-reported measures of use, 32.1% of the population studied *appropriately* used evidence in their clinical practice.[13]

Given a 32.1% (P) rate of expected self-reported appropriate use of evidence, and a total sampling frame (N) of 685 CICM registered Intensive Care Specialists, standard formulas for simple random samples calculated a survey of **238** (n*) Intensive Care Specialists would provide a precision (L) of 5% on the estimate of self-reported appropriate use, with adjustments for the sampling fraction (n/N) being greater than 10% of the total population.[16]

Survey Administration

Pre-numbered survey packages were collated by the primary researchers and provided to the CICM along with a computer-generated list of random numbers. The CICM then handled the labelling and mail out of the survey packages to maintain the confidentiality and anonymity of the sample population. The survey was administered by direct mail out and a reply paid (stamped) response envelope was provided in the package.[17]

A cover letter presented with the survey package outlined the purpose of the project, requested participation through completion and return of the accompanying questionnaire and assured respondents of confidentiality and anonymity.[18]

When returned, member numbers were recorded and removed from the respondents list. Two repeat mail outs were conducted to member numbers not marked as returned, following the same procedures as the initial mail out.[15;19]

Survey Instrument Design

The survey instrument questionnaire comprising five sections (demographics; research experience; research knowledge; research attitudes and research use) was developed based upon a comprehensive review of the literature. Previously published surveys evaluating attitudes towards, and the use of, EBM were found by searching MEDLINE using the key search terms 'evidence based medicine' AND 'physician attitude' AND 'questionnaire.' To assure content and construct validity, articles were retrieved and reviewed for content, with a list of themes, topic areas and specific questions collated and included in our survey. Selection and wording of our questions was based on our review of topic related publications, with a major focus on the survey published by DeVito et al[13], adapted to the Australian setting of intensive care medicine. The revised questionnaire was pilot tested on three individuals practicing in intensive care. Pilot testers were asked to (a) review each individual question and make comments on what they thought it was asking, clarity of wording whilst (b) also completing the questionnaire in full. All responses and feedback from pilot testing were

reviewed by the two authors and questions were modified to incorporate feedback and ensure clarity. One iteration of pilot testing was undertaken.

A copy of the survey is provided in appendix 1.

Data Entry

All data from returned survey questionnaires was entered into a Microsoft Excel™ database and re-checked for accuracy following initial entry. An external researcher not directly involved with this project then audited accuracy of data transcription. Fifty percent of all records were audited.

Statistical Analysis

Descriptive statistics are presented. Results are reported as median with frequencies (percent); mean and standard deviation; or rates, with numerator and denominator.

(3) Results:

Response rate

The survey instrument questionnaire was sent to the sample population in three consecutive mail outs in January, February and March 2011. After the first mail out 72 out of 238 questionnaires were returned; an additional 17 surveys were returned after the second mail out; and 42 following the third mail out. Promotion by the CICM (at their annual conference and in their newsletter) resulted in receipt of a further two surveys. Of the original sample of 238 Intensive Care Specialists randomly selected from the CICM registration list, a total of 133 returned the questionnaire, giving an overall unit response rate of 55.88% (133/238). Item response rate for individual questions in the returned questionnaires was between 97% (129/133) and 99.25% (132/133).

Data Entry

Fifty percent of all records were audited, zero errors were found.

Characteristics of Respondents

The average number of years practising as a Registered Intensive Care Specialist was 15 years (SD 7.0 years) with a mean age of 51 (SD 8.57 years). Males made up 81.53% (106/130) of respondents.

Some form of research training (research fellowship; formal research methodology course; or Certificate, Diploma or Degree in research methodology) had been completed by 31.06% (41/132) of respondents. Additionally, 40.77% (53/130) of respondents reported completion of some level of formal Evidence Based Medicine (EBM) training (attended an EBM course/workshop conducted at a hospital, conference, other organisation or university).

Full details of characteristics of respondents can be found in *Table 1*.

Research Knowledge

To assess research knowledge, respondents were provided with six statements and asked to select *correct*, *incorrect* or *not sure* for each statement. See *Table 2* for complete list of knowledge statements. Question 4, concerning the accepted level of statistical significance (p<0.05), received the most correct responses (96.15% (125/130)), whereas Question 5, addressing measures of heterogeneity (I^2), received the least number of correct responses (14.73% (19/129)).

The average score out of six for research knowledge was 2.92 (SD 1.59). The number of respondents correctly identifying all 6 correct responses was 2.30% (3/130). Full details of participants' responses to individual knowledge statements are summarised in *Table 2*.

Research Attitudes

Six statements concerning attitudes and feelings towards aspects of research were provided; with five options for response ranging from *strongly disagree* to *strongly agree*. Positive feelings (*agree* or *strongly agree*) towards using published research evidence in clinical practice were reported by 65.39% (85/130) of respondents, and 75.39% (98/130) of respondents also reported that their colleagues had positive feelings (*agree* or *strongly agree*) towards using published research evidence in clinical practice.

Responding Intensive Care Specialists reported the highest level of positive feelings (86.15% (112/130) *agreed* or *strongly agreed*) in regards to using the results of an RCT to guide their clinical practice, with less Intensive Care Specialists reporting positive feelings about using the results of a systematic review/ meta-analysis to guide their clinical practice (59.23% (77/130) *agreed* or *strongly agreed*).

Frequency of Research Use

When responding to a question that asked respondents to rate the *frequency of use* of the concepts of EBM in their own clinical practice, 96.62% (126/130) of Intensive Care Specialists reported that they use EBM *at least sometimes,* which was defined as 'every month or so'.

Responding to a question regarding the *frequency of reading* different sources of evidence, Intensive Care Specialists rated RCT's to be the *most frequently read* evidence source, with a mean rank score of 3.73 (SD 0.67) and 97.69% (127/130) of respondents reporting they read RCTs *at least sometimes*. Information obtained from the Cochrane Library ranked lowest with a mean rank score of 2.81 (SD 0.86) and 65.12% (84/129) of respondents reporting *at least sometimes* using this evidence source. Complete details regarding frequency of reading specific evidence sources are reported in *Table 3*.

In a question regarding how often various information sources are *used to guide decisions in clinical practice*, Published Evidence Based Guidelines (EBG's) were ranked by respondents as the *most often used* information source to guide clinical decisions, with a mean rank score of 3.58 (SD 0.68) and 96.92% (126/130) of respondents reporting *at least sometimes* using this evidence source. The results of a Cochrane review were rated as the *least often used* information source with a mean rank score of 2.80 (SD 0.74) and *at least sometimes* use reported by 67.69% (88/130) of respondents. Complete details regarding frequency of use of specific evidence sources to guide clinical decision making are reported in *Table 4*.

Table 5 provides details regarding the reported frequency of use of published research evidence in various situations other than clinical practice, such as teaching, talking to family or patients etc.

Factors that Influence and Inhibit Use of Published Research Evidence

Respondents were given a list of potential influencing factors and asked whether the factors *help* their decision to use the results of published research evidence to change clinical practice. Respondents rated *'the results have clear benefit to my patients'* as the most helpful factor with a mean rank score of 4.36 (SD 0.53), with 100% of respondents (129/129) selecting *at least sometimes* for this factor. The factor that was rated as the least helpful was that *'the paper presents a full economic analysis'* with a mean rank score of 2.82 (SD 0.94), with 62.02% (80/129) of respondents selecting *at least sometimes* for this factor.

The respondents were then asked to rate factors that *inhibit* the use of published research evidence in their clinical practice. The statement *'there is a lack of good evidence providing meaningful answers to clinical problems'* was selected as the most inhibiting factor with a mean rank score of 3.54 (SD 0.90) and 87.6% (113/129) of respondents selecting *at least sometimes.* The least inhibiting factor was *'appraising published research papers is not part of my role'* with a mean rank score of 2.12 (SD 0.89), and *at least agree* selected by 10.08% (13/129) of respondents.

When asked specifically to identify whether time limitations are a factor that restrict the incorporation of Evidence Based Medicine (EBM) into their clinical practice, the mean rank score was 2.68 (SD 1.02) and 26.92% (35/130) of respondents reporting *at least agree*.

Level of Appropriate Use of Published Research Evidence in Practice

As ascertained using the previously published tool by De Vito et al., 67.69% (88/130) of Intensive Care Specialists in Australia and New Zealand were rated as self reported *appropriate users* of published research evidence in clinical practice; that is 'they read sometimes, often or very often RCTs and meta-analyses and use the results of RCTs and meta-analyses in clinical practice'.[13]

(4) Discussion:

We conducted a mail out survey of qualified Intensive Care Specialists from Australia and New Zealand to explore their knowledge, attitudes and appropriate use of published research evidence in clinical practice. The responding Intensive Care Specialists reported overwhelmingly *positive attitudes*

towards published research evidence, with a *moderate level of appropriate use* in clinical practice; however, this survey highlighted room for improvement in technical knowledge relating to published research evidence.

Attitudes towards published research evidence:

Prochaska's seminal 'stages of change model' proposes that an awareness of the need for change and a positive attitude to the benefits of change are the necessary first steps to undertaking a successful change management process.[20] The 'Theory of Planned Behaviour' further highlights the importance of attitudes, with a positive attitude defined as one of three major characteristics that determine the likelihood of someone changing their behaviour.[8] It would appear that there has been a cultural shift in attitudes towards EBM since its inception in the early 90's, with the majority of recent studies now showing generally positive attitudes towards the concepts of EBM.[9,10,12,13,21-24] However, there are varied attitudes towards specific aspects of the use of evidence in practice amongst some clinical specialties within medicine. For example, a survey of Australian surgeons reported ambivalent and contradictory attitudes towards the use of published research evidence in practice, with surgeons reporting high confidence in their own judgement compared with low confidence in clinical practice guidelines relative to other sources of evidence.[25] In contrast to surgeons' attitudes, the majority of qualified Intensive Care Specialists within Australia and New Zealand responding to our survey reported positive attitudes towards the use of published research evidence along with an overwhelming perception that colleagues' attitudes towards published research evidence were positive. Having positive attitudes logically translates into being more likely to use published research evidence in clinical practice.[26]

Appropriate Use:

There are few repeatable objective definitions published regarding *appropriate use* of published research evidence in clinical practice. A survey conducted in Italian physicians by De Vito et al. provides a working template of *appropriate use,* defined as 'read sometimes, often or very often RCT's and meta-analyses, and use the results of RCT's and meta-analyses in clinical practice'.[13] In order to be able to compare the levels of appropriate use of published research evidence in clinical practice by our respondents to those previously published, we asked the same questions as De Vito et al.[13]

Significantly more Australian and New Zealand Intensive Care Specialists reported fulfilling this self-reported criteria of appropriate use of published research evidence in clinical practice than Italian physicians (67.69% (88/130) vs 32.1% (209/654), p<0.0001). Furthermore, respondents reported a preference towards RCTs over systematic reviews.

In the '6S model', a hierarchical framework for accessing preappraised evidence, Haynes and colleagues propose that clinicians should seek systematic reviews in preference to RCTs when looking for evidence to support their clinical decision making.[27] Major credible bodies, such as the Oxford Centre for Evidence Based Medicine, further advocate systematic reviews as representing the highest level of evidence on which to base clinical treatment decisions.[28,29] Despite these recommendations, our survey showed Intensive Care Specialists place meta-analyses and Cochrane reviews lower than RCTs in their preferences of evidence sources used to guide clinical decision making. The number of large scale multi-centre clinical trials being conducted in Intensive Care Units within Australia and New Zealand is increasing rapidly each year[30] which is reflected in the majority of respondents reporting participation in some form of clinical trial activity (93.13%), such as consenting patients for participation in clinical trials, acting as a site investigator, or publishing research papers. The experience gained through involvement and participation in large scale RCTs may have influenced the expressed preference amongst Australian and New Zealand Intensive Care Specialists for using the results of an RCT to guide clinical practice over a systematic review/meta-analysis.

Knowledge:

Although respondents reported a good level of knowledge of basic research evidence concepts, such as the accepted level of statistical significance in clinical trials (p<0.05 threshold), we found much lower levels of knowledge as questions were asked relating to more technical aspects of research evidence, such as measures of heterogeneity in meta-analyses (I^2 metric). Good basic knowledge is consistent with the findings of De Vito et al. which showed Italian physicians level of knowledge also decreased as faced with more technical questions.[13] Alongside positive attitudes, an awareness and understanding of the need for change is identified as important to the success of implementing a change in behaviour.[20] Improved knowledge regarding research methods may lead to an increased

understanding of the need for change thus enhancing *appropriate* use of published research evidence in clinical practice.

Barriers to use:

The Intensive Care Specialists responding to our questionnaire ranked the belief that *'there is a lack of good evidence providing meaningful answers to my clinical problems'* as the factor that most inhibits their use of published research evidence in clinical practice. Other studies consistently cite lack of time as the biggest barrier to the implementation of research evidence into practice.[9,10,21,23] In our survey, having *'difficulties finding the time to read'* ranked third in a list of 13 potential inhibiting factors, and when directly asked to identify whether *'time limitations were a factor that restricted the incorporation of research evidence into their clinical practice'*, only one quarter of respondents agreed or strongly agreed. This perhaps highlights that whilst finding the time to read published research evidence remains a potential barrier, reading research evidence is now more widely accepted as part of the medical role.

Strengths and Limitations:

Metric of Appropriate Use

The level of appropriate use of published research evidence in clinical practice was assessed based on a construct previously published in a large well conducted survey of physicians in Italy.[13] Whilst the components of the tool were not comprehensive, they were easily repeatable and thus enabled us to make a comparison of the levels of self-reported appropriate use found in our population. It must be noted that all measures of appropriate use obtained in this survey were *based solely* on self-reporting and may therefore not reflect true rates of appropriate use. The measure of appropriate use utilised is an arbitrary metric and it is unknown whether it is the most suitable way to measure appropriate use. It is also worth acknowledging that whilst the measure was defined in the Italian survey, the authors did not set a level of appropriate use that was deemed acceptable.

Response Rates

We achieved a response rate of 56% (133/238). We used optimal survey methodology from the Dillman Total Design Method,[15,31,32] and gained the support of the local Intensive Care professional

college (CICM)[18] to attempt to maximise response rates. Due to funding limitations, we were unable to consider the use of financial incentives and it is unclear if this may have had an effect on our response rate.[33] Despite optimal survey methodology we did not reach our desired response rate of 70%, however our response rate is similar to average rates achieved in other contemporaneous physician surveys with similar design.[34,35]

Generalisability

It is possible Intensive Care Specialists with positive attitudes towards published research evidence, such as those with academic affiliations, would be more likely to respond to a survey regarding research. We cannot exclude that this may have biased the levels of self-reported appropriate use in our survey. Demographic data regarding non-responders was not available when evaluating our response rate, addressing any potential non-responder bias and assessing the external validity of our findings. We were therefore unable to compare non-responders to responders. The results of our survey may therefore not be generalisable to all Intensive Care Specialists and must be interpreted as such.

Bias within survey design

Whilst all attempts were made to minimise bias through use of The Dillman Total Design Method[15] it is possible that bias is present based upon the order, wording and framing of the questions contained in our survey.

Recommendations:

Although self-reported appropriate use (as ascertained by the tool developed by De Vito et al)[13] in Australian and New Zealand Intensive Care Specialists was better than that found in Italian physicians, a moderate level of appropriate use may indicate room for improvement. However, as acceptable levels of appropriate use have not specifically been defined, further research is needed using more direct methods, such as interpretation of clinical decision making scenarios or observations of use of research evidence in clinical practice to evaluate true rates of appropriate use and to define what is an acceptable rate of appropriate use. More research is also required to assess the depth, reliability and validity of these measures of appropriate use.

Whilst the results of our survey have reinforced ideas from prominent change theorists that promote attitudes and understanding as important components of a successful change management process, there are few studies that actually attempt to measure and quantify these factors in relation to rates of appropriate use of published research evidence. Improving knowledge may lead to a greater understanding of the need to change practice based upon the results of published research evidence. Strategies to improve knowledge such as participation in research training and Evidence Based Medicine courses may be of potential benefit. We recommend that when future research is conducted on measures of appropriate use, measures of the influence and association between attitudes and knowledge and appropriate use be included. This will enable us to gain a better understanding of how these attributes influence the use of published research evidence in clinical practice.

Despite recommendations from key authoritive bodies that systematic reviews should be used over RCTs to guide clinical decision-making, the results of our survey show our population still prefer RCTs. This highlights an opportunity for researchers to increase awareness and understanding of the role of systematic reviews and meta-analyses and other types of evidence summaries. Further research may be required to investigate strategies for improving trust and confidence in these evidence sources.

Concluding summary:

Based on the responses to our survey, it is evident that Australian and New Zealand Intensive Care Specialists face similar research adoption challenges as those in other fields. Study respondents had positive attitudes towards using published research evidence in clinical practice and a moderate level of self-reported appropriate use despite lower than expected knowledge levels. Surveys in other fields report that 'attitudes' towards EBM are generally positive,[11,12,36,37] however there is a high reliance upon traditional information sources, such as consulting colleagues or textbooks,[22,38-40] with a lack of time and EBM skills emerging as the most frequently reported barriers.[9,21,36,37] Further research is required to expand our understanding of the influence of knowledge and attitudes on use of published research evidence in clinical practice.

References:

(1) Evidence-based Medicine Working Group. Evidence-based medicine. A new approach to teaching the practice of medicine. *JAMA* 1992;268:2420-2425.

(2) Buchan H. Gaps between best evidence and practice: causes for concern. *Med J Aust* 2004;180:S48-S49.

(3) Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet* 2003;362:1225-1230.

(4) Institute of Medicine. Best Care at Lower Cost: The Path to Continuously Learning Health Care in America. 1-360. 6-9-2012. Washington DC, Institue of Medicine Consensus Report.

(5) Cummings KL, Anderson DJ, Kaye KS. Hand hygiene noncompliance and the cost of hospital-acquired methicillin-resistant Staphylococcus aureus infection. *Infect Control Hosp Epidemiol* 2010;31:357-364.

(6) O'Boyle CA, Henly SJ, Larson E. Understanding adherence to hand hygiene recommendations: the theory of planned behavior. *Am J Infect Control* 2001;29:352-360.

(7) Tonelli MR, Curtis JR, Guntupalli KK et al. An official multi-society statement: the role of clinical research results in the practice of critical care medicine. *Am J Respir Crit Care Med* 2012;185:1117-1124.

(8) Ajzen I. *Attitudes, Personality and Behaviour*. 2 ed. Berkshire: Open University Press, 2005.

(9) McColl A, Smith H, White P, Field J. General practitioner's perceptions of the route to evidence based medicine: a questionnaire survey. *BMJ* 1998;316:361-365.

(10) Young JM, Ward JE. Evidence-based medicine in general practice: beliefs and barriers among Australian GPs. *J Eval Clin Pract* 2001;7:201-210.

(11) Veness M, Rikard-Bell G, Ward J. Views of Australian and New Zealand radiation oncologists and registrars about evidence-based medicine and their access to Internet based sources of evidence. *Australas Radiol* 2003;47:409-415.

(12) Dahm P, Poolman RW, Bhandari M et al. Perceptions and competence in evidence-based medicine: a survey of the American Urological Association Membership. *J Urol* 2009;181:767-777.

(13) De Vito C, Nobile CG, Furnari G et al. Physicians' knowledge, attitudes and professional use of RCTs and meta-analyses: a cross-sectional survey. *Eur J Public Health* 2009;19:297-302.

(14) Halpern NA, Bettes L, Greenstein R. Federal and nationwide intensive care units and healthcare costs: 1986-1992. *Crit Care Med* 1994;22:2001-2007.

(15) Dillman DA. *Mail and telephone surveys: the Total Design Method*. New York: Wiley, 1978.

(16) Martin SW, Meek.A.H, Willenberg.P. Sampling Methods. *Veterinary Epidemiology: Principles and Methods*. Ames: Iowa State University Press, 1987;32-33.

(17) Urban N, Anderson GL, Tseng A. Effects on response rates and costs of stamps vs business reply in a mail survey of physicians. *J Clin Epidemiol* 1993;46:455-459.

(18) VanGeest JB, Johnson TP, Welch VL. Methodologies for improving response rates in surveys of physicians: a systematic review. *Eval Health Prof* 2007;30:303-321.

(19) Dillman DA, Smyth JD, Christian LM. *Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method.* 3rd ed. New Jersey: John WIley Co., 2009.

(20) Prochaska JO, Velicer WF. The transtheoretical model of health behaviour change. *American Journal of Health Promotion* 1997;12:38-48.

(21) Al-Kubaisi NJ, Al-Dahnaim LA, Salama RE. Knowledge, attitudes and practices of primary health care physicians towards evidence-based medicine in Doha, Qatar. *East Mediterr Health J* 2010;16:1189-1197.

(22) McAlister FA, Graham I, Karr GW, Laupacis A. Evidence-based medicine and the practicing clinician. *J Gen Intern Med* 1999;14:236-242.

(23) Ten Bruggencate MJ, Kremer LC, Caron HN, Knops AM, van Dalen EC. Pediatric oncologists and evidence-based medicine: a postal survey in The Netherlands. *Pediatr Blood Cancer* 2009;52:231-236.

(24) Risahmawati RR, Emura SS, Nishi TT, Koizumi SS. Japanese Resident Physicians' Attitudes, knowledge, and Perceived Barriers on the Practice of Evidence Based Medicine: a Survey. *BMC Res Notes* 2011;4:374.

(25) Kitto S, Villanueva EV, Chesters J, Petrovic A, Waxman BP, Smith JA. Surgeons' attitudes towards and usage of evidence-based medicine in surgical practice: a pilot study. *ANZ J Surg* 2007;77:231-236.

(26) Davis DA, Taylor-Vaisey A. Translating guidelines into practice. A systematic review of theoretic concepts, practical experience and research evidence in the adoption of clinical practice guidelines. *CMAJ* 1997;157:408-416.

(27) Dicenso A, Bayley L, Haynes RB. Accessing pre-appraised evidence: fine-tuning the 5S model into a 6S model. *Evid Based Nurs* 2009;12:99-101.

(28) Phillips B, Ball C, Sackett D, Badenoch D, Straus S, Haynes B et al. Oxford Centre for Evidence-based Medicine; Levels of Evidence. 2009. Oxford, Centre for Evidence Based Medicine.

(29) OCEBM Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence". 2013. Oxford, Oxford Centre for Evidence-Based Medicine.

(30) ANZICS CTG. ANZICS Clinical Trials Group: Activity Report 2011-2012. 1-44. 2012. Carlton Victoria, ANZICS CTG.

(31) Edwards P, Roberts I, Clarke M et al. Methods to increase response rates to postal questionnaires. *Cochrane Database Syst Rev* 2007;MR000008.

(32) Griffith LE, Cook DJ, Guyatt GH, Charles CA. Comparison of open and closed questionnaire formats in obtaining demographic information from Canadian general internists. *J Clin Epidemiol* 1999;52:997-1005.

(33) Thorpe C, Ryan B, McLean SL et al. How to obtain excellent response rates when surveying physicians. *Fam Pract* 2009;26:65-68.

(34) Asch DA, Jedrziewski MK, Christakis NA. Response rates to mail surveys published in medical journals. *J Clin Epidemiol* 1997;50:1129-1136.

(35) Field TS, Cadoret CA, Brown ML et al. Surveying physicians: do components of the "Total Design Approach" to optimizing survey response rates apply to physicians? *Med Care* 2002;40:596-605.

(36) Heselmans A, Donceel P, Aertgeerts B, Van d, V, Ramaekers D. The attitude of Belgian social insurance physicians towards evidence-based practice and clinical practice guidelines. *BMC Fam Pract* 2009;10:64.

(37) Heselmans A, Donceel P, Aertgeerts B, Van d, V, Ramaekers D. The attitude of Flemish occupational health physicians toward evidence-based occupational health and clinical practice guidelines. *Int Arch Occup Environ Health* 2010;83:201-208.

(38) Oliveri RS, Gluud C, Wille-Jorgensen PA. Hospital doctors' self-rated skills in and use of evidence-based medicine - a questionnaire survey. *J Eval Clin Pract* 2004;10:219-226.

(39) Ahmadi-Abhari S, Soltani A, Hosseinpanah F. Knowledge and attitudes of trainee physicians regarding evidence-based medicine: a questionnaire survey in Tehran, Iran. *J Eval Clin Pract* 2008;14:775-779.

(40) Ulvenes LV, Aasland O, Nylenna M, Kristiansen IS. Norwegian physicians' knowledge of and opinions about evidence-based medicine: cross-sectional study. *PLoS One* 2009;4:e7828.