Evidence-based implementation of evidence-based asthma guidelines in rural hospital emergency departments

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A thesis submitted to meet the requirements of the degree
Doctor of Philosophy (by publication), School of Medicine and Public Health, Faculty of Health, University of Newcastle, Australia.
DECLARATION

I certify that the work embodied in this thesis is the result of original research and has not been submitted for recognition towards a higher degree at any other University or institution.

__________________
Steven Doherty

__________________
Date
DEDICATION

For my parents, John and Irene, who left their homeland in 1970 hoping to provide a better future for their family and provided the foundation for my career.
Acknowledgements

There are numerous people and organisations I would like to acknowledge for without them this body of work would never have been completed.

Firstly I would like to thank the staff at the National Institute of Clinical Studies (NICS) which is now a part of the NHMRC. NICS leads the way in reducing evidence-practice gaps in Australia. The three year NICS fellowship I was awarded was the trigger to develop this work into a thesis. Special mention should go to Sue Huckson and Rosie Forster whose roles in the fellowship program were substantial and greatly appreciated.

NICS appointed a leadership mentor, Dr Greg Stewart, who has been supportive of this work even after the fellowship elapsed. My NICS project mentor was also my PhD supervisor, Professor Peter Jones. Peter has been a huge support not only in driving me to pursue a PhD but also in his advice at all levels. His supervision has been greatly appreciated.

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My co-authors on a number of the published papers included Professor Peter Jones, Dr Nick Ryan, Lin Davis, Helen Stevens, Verity Treeve, Dr Paul Leschke, Dr Anna Valpiani, Dr Emma Whitely and Dr Della Yarnold. I thank them for their efforts in the overall program of improving clinical practice as well as assistance with their respective studies.

I must thank all the staff, medical, nursing and clerical at the 12 hospitals in the former New England (now Hunter New England) Area Health Service for being prepared to embrace some changes in practice and providing access to records as required for the studies.

Finally, thanks to my wife Claire who has always been supportive of my clinical and academic life.
PUBLICATIONS INCORPORATED INTO THIS THESIS AND AUTHORSHIP STATEMENTS

This thesis includes nine peer reviewed publications in Emergency Medicine Australasia (3), International Journal of Health Care Quality Assurance (2), British Medical Journal (1), Journal of Paediatrics and Child Health (1), Rural and Remote Health (1) and the NHMRC website / NICS evidence into practice series (1).

In addition the British Medical Journal publication resulted in a number of rapid responses and replies. These are included in the relevant chapter, Chapter 5.

The International Journal of Health Care Quality Assurance was chosen as an appropriate quality journal to publish the proposed methodology, which was substantial, and generally of minimal interest to clinical staff. This allowed a brief summary of the methodology in the articles targeted at clinicians. Emergency Medicine Australasia, Journal of Paediatrics and Child Health and Rural and Remote Health were the most appropriate Australasian journals for the target clinicians. The British Medical Journal Change page was an appropriate forum for presenting evidence of the need for change.

I was the single author of the following 5 papers


3. Doherty SR. Prescribe systemic corticosteroids in acute asthma. BMJ 2009;338:b1234


One co-authored paper has a statement attesting to my principal authorship included in the published version. That paper is as follows.


Three other papers were co-authored and for all papers I was the principal author, drafted the manuscript, led the implementation team, developed the study design and concept, adapted and developed the guideline and performed the statistical analyses. Statements attesting to this, from all co-authors are included.


**COMPETING INTERESTS**

At the time of publication of the articles in Emergency Medicine Australasia, Steven Doherty was a section editor of that journal, though not involved in review of these papers. This competing interest is declared on each paper where relevant.

*Associate Professor Steven Doherty*
PRESENTATIONS RELATED TO THIS THESIS

In addition to the above publications a number of peer reviewed and invited presentations related to this thesis have been given. These presentations are listed below.

Doherty, Steven. Development of an evidenced based implementation for rural EDs
Australian Research Alliance for Children and Youth
“Closing the Know-do Gap” Conference, July 2005
Peer reviewed conference oral presentation. Abstract and Power Point presentation on website

Peer reviewed conference oral presentation. Abstract published in conference proceedings

Doherty, Steven. Clinical Guidelines in the ED- An Evidence-Based Implementation.
Australasia College of Emergency Medicine Winter Symposium, 20-23 July 2005, Queenstown, New Zealand
Peer reviewed conference oral presentation. Abstract published in conference proceedings

Doherty, Steven. Results of evidenced implementation across a spectrum of hospitals. NSW Health Rural Critical care Winter Conference, September 2005
Peer reviewed conference oral presentation.


Doherty S. "Overcoming the Gap" in Rural Health Australasian College for Emergency Medicine Annual Scientific Meeting – Invited presentation, peer reviewed meeting, Sydney, November 20, 2006.


Statements of Authorship

AUTHORSHIP STATEMENT


We the undersigned agree that,

Steven Doherty was the principal author of this paper, drafted the manuscript, developed the study concept and design and performed the statistical analyses.

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Dr Della Yarnold

Ms Helen Stevens
AUTHORSHIP STATEMENT


We the undersigned agree that,

Steven Doherty was the principal author, drafted the manuscript, led the implementation team, developed the study design, adapted and developed the guideline and performed the statistical analyses in the above paper.

Professor Peter Jones

Ms Helen Stevens

Ms Lin Davis

Dr Nicholas Ryan

Ms Verity Treeve
AUTHORSHIP STATEMENT

Doherty SR, Jones PD. Use of an evidence-based implementation strategy to implement evidence-based care of asthma into rural district hospital emergency departments. Rural and Remote Health. 6:529 (online) 2006.

I, Peter Jones, confirm that Steven Doherty drafted the manuscript, led the implementation team, developed the study design, adapted and developed the guideline and performed the statistical analyses in the above paper.

Professor Peter Jones
# Table of contents

Acknowledgements ............................................................................................................................... i
Statements of Authorship .................................................................................................................... vi
List of Appendices ................................................................................................................................. x
List of Abbreviations ............................................................................................................................... i
Abstract .................................................................................................................................................. 2

## Chapter 1: Introduction ................................................................................................................................. 4
  1.1 Historical Setting ................................................................................................................................. 4
  1.2 Rural Emergency Medicine ............................................................................................................... 6
  1.3 Evidence-Based medicine .................................................................................................................. 7
  1.4 Thesis Aims ......................................................................................................................................... 8
  1.5 Thesis Outline ................................................................................................................................... 8

References .................................................................................................................................................. 11

## Chapter 2: Evidence-Based Treatment of Acute Asthma. A Review of Meta-analyses on the Cochrane Database .............................................................................................................................................. 13
  2.1 Introduction ......................................................................................................................................... 13
  2.2 Methods ............................................................................................................................................. 13
  2.3 Results ................................................................................................................................................ 13
  2.4 Discussion ......................................................................................................................................... 20
  2.5 Conclusion ....................................................................................................................................... 23

References .................................................................................................................................................. 24

## Chapter 3: Literature Review: Developing an Evidence-Based Implementation .............................................. 27
  3.1 Introduction ......................................................................................................................................... 27
  3.2 Knowledge Translation in Context ..................................................................................................... 27
  3.3 Developing an Evidence Based Implementation Strategy .................................................................... 31
  3.4 Evidence based implementation ......................................................................................................... 31
  3.5 Evidence for Implementation Strategies ........................................................................................... 33
  3.6 Identifying Barriers to Change ......................................................................................................... 35
  3.7 Summary .......................................................................................................................................... 37

References .................................................................................................................................................. 38

## Chapter 4: Understanding Evidence-Based Medicine .................................................................................. 41

## Chapter 5: Presenting Evidence .................................................................................................................. 59

## Chapter 6: Evidence-Based Implementation ............................................................................................ 71

## Chapter 7: Trials of Evidence-Based Implementation of Asthma Guidelines .............................................. 82

## Chapter 8: Audit in Quality Improvement Research .................................................................................. 108

## Chapter 9: Discussion ............................................................................................................................... 117
  9.1 Translational Research ....................................................................................................................... 117
  9.2 Translational Blocks .......................................................................................................................... 118
  9.3 Barriers to Change .............................................................................................................................. 120
  9.4 Evidence-Based Implementation ....................................................................................................... 122
  9.5 The Ethical Argument for Translational Research ............................................................................. 123
  9.6 Data Collection ................................................................................................................................. 124

References .................................................................................................................................................. 124

Appendices .................................................................................................................................................. 129
List of Appendices

Appendix 1: History, pathophysiology, clinical presentation and role of hyperbaric oxygen in acute carbon monoxide poisoning ................................................................. 130
Appendix 2: Adult Asthma – ED Guideline ................................................................................. 145
Appendix 3: Paediatric Asthma – ED Guideline ....................................................................... 146
Appendix 4: Paediatric Asthma Teleform .................................................................................. 147
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGREE</td>
<td>Appraisal of Guidelines for Research and Evaluation</td>
</tr>
<tr>
<td>CEC</td>
<td>Clinical Excellence Commission</td>
</tr>
<tr>
<td>CECP</td>
<td>Children’s Emergency care project</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
<tr>
<td>CPG</td>
<td>Clinical Practice Guideline</td>
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<tr>
<td>EBI</td>
<td>Evidence Based Implementation</td>
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<td>EBM</td>
<td>Evidence Based Medicine</td>
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<tr>
<td>ED</td>
<td>Emergency Department</td>
</tr>
<tr>
<td>FEV1</td>
<td>Forced Expiratory Volume in 1 second</td>
</tr>
<tr>
<td>FVC</td>
<td>Forced Vital Capacity</td>
</tr>
<tr>
<td>GLIA</td>
<td>Guideline Implementability Appraisal</td>
</tr>
<tr>
<td>GP</td>
<td>General Practitioner</td>
</tr>
<tr>
<td>HBO</td>
<td>Hyperbaric Oxygen</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>IM</td>
<td>Intramuscular</td>
</tr>
<tr>
<td>MRC</td>
<td>Medical Research Council</td>
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<tr>
<td>NAC</td>
<td>National Asthma Council</td>
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<tr>
<td>NHMRC</td>
<td>National health and Medical Research Council</td>
</tr>
<tr>
<td>NICS</td>
<td>National Institute of Clinical Studies</td>
</tr>
<tr>
<td>NIV</td>
<td>Non-Invasive Ventilation</td>
</tr>
<tr>
<td>NNT</td>
<td>Number Needed to Treat</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>PEFR</td>
<td>Peak Expiratory Flow Rate</td>
</tr>
<tr>
<td>PFT</td>
<td>Pulmonary Function Tests</td>
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<tr>
<td>PO</td>
<td>Per Oral</td>
</tr>
<tr>
<td>QI</td>
<td>Quality Improvement</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
</tr>
<tr>
<td>RR</td>
<td>Relative Risk</td>
</tr>
<tr>
<td>VMO</td>
<td>Visiting Medical Officer</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
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Abstract

Knowledge translation refers to the process whereby the findings from high quality clinical research are incorporated into clinical practice. Knowledge translation is therefore a key step in improving health care and ensuring that the benefits of clinical research flow onto patients. A gap currently exists between research and clinical practice because of uncertainty surrounding the best strategies to achieve knowledge translation. Evidence-Based Implementation is a concept that builds on the principals of evidence-based medicine and can be described as judicious use of the best available evidence to implement change in health care systems.

This thesis describes a body of work that lead to the development of an Evidence-Based Implementation (EBI) strategy for asthma management in rural emergency departments. The strategy was based on a review of the existing literature about achieving change in clinical practice, and the participation of the author in several workshops during a three year National Institute of Clinical Studies Research Fellowship, that sought to indentify the core elements required to achieve changes in clinical behaviour. At the time this study was being developed the literature indicated that a 10% improvement in clinical care would represent a successful implementation project. The hypothesis posed in this body of research was that greater improvements in the proportion of patients receiving care consistent with best practice could be achieved through using an EBI.

Asthma was chosen as the clinical condition to test the effectiveness of an EBI. Asthma was chosen because it is a common presentation to all Emergency Departments. There was also an abundance of literature available that allowed the development of a range of clinical indicators that would signal that a patient with asthma had received evidenced based, best practice health care. These markers also allowed the impact of the EBI to be accurately measured. Small and large rural Emergency Departments were used to assess the EBI in the format of controlled and before and after trials to further improve the validity of the estimated impact on clinical behaviour. These departments were individual workplace settings separated by hundreds of kilometres.

Key elements of the EBI strategy used in these studies included use of reminders, audit and feedback, outreach visits and education, anticipating barriers to change and use of opinion leaders. The evolution of the author as a broker between clinical practice and knowledge translation is another element that is discussed within the
thesis. These elements were chosen as they were considered to be the most relevant for the clinical environments studied, this constitutes the judicious aspect of an EBI.

Each of the studies in this series of papers demonstrated that the EBI strategy was able to achieve improvements in clinical indices of effective asthma management of 20-40% above baseline levels of clinical performance. This thesis demonstrates that in the environment of the rural emergency department, clinical indices for best practice asthma care can be improved using an EBI strategy. Further research is required to document if such improvements in clinical performance lead to actual improvements in patient outcomes and whether this approach to knowledge translation is applicable to other clinical scenarios. Further research is also required to determine which components of the EBI strategy had greatest impact in changing clinician behaviour.
Chapter 1: Introduction

In this chapter I will briefly review some colourful historical examples surrounding the development of evidence in clinical medicine. These examples serve to demonstrate that many of the principles underpinning evidence-based medicine are in fact quite old, and some of these examples also touch on the difficulties of getting new evidence into clinical practice, a process known as knowledge translation.

Applying evidence-based medicine in the emergency department setting is at the core of this thesis and hence in this chapter I will also briefly provide the context of the practice of emergency medicine in the rural setting and also briefly clarify what evidence-based medicine is and how I became interested in it.

Finally the aims of this thesis will be presented and an overview of the outline of the thesis will be provided.

1.1 Historical Setting

The Medical Research Council (MRC) Trial of streptomycin in pulmonary tuberculosis\(^1\) has been cited\(^2\) as the first published randomized trial. Published in 1948 this trial began after another MRC trial on whooping cough vaccination\(^3\) which was not published until 1951. The history of randomization and controlled trials, however, began well before the middle of the 20\(^{th}\) century.

In 1747 James Lind\(^4\) built on the work of James Lancaster, a seaman, who in 1591 led an expedition to the East Indies. The chronicler of that expedition noted that men suffering from scurvy made a full recovery after eating oranges and lemons on the island of St Helena. This evidence, from observation, meant that in 1601 when Lancaster led a second expedition to the East Indies the men on his ship did not get scurvy. This was attributed to the “juice of lemons” of which each man received three spoonfuls each morning.

By Lind’s day a number of anecdotal cures for scurvy were advocated including citrus fruits. James Lind, a Scottish surgeon, randomized 12 men into 6 groups of 2. The cases were, “…as similar as I could have them…putrid gums, the spots and lassitude and weakness of their knees.”\(^4\) The two men receiving oranges and lemons made a dramatic recovery.
Lind’s trial is considered to be one of the first randomized trials. For this thesis it is also of interest because it took seven years for these results to be published as a “treatise of the scurvy” and another 40 years before the Royal Navy added lemon juice to the royal ships. It took a long time for Lind’s findings to become common practice and today, despite the advent of the internet, other barriers can delay the uptake of evidence into practice.

The concept of randomization was already over one hundred years old by the time of Lind’s study. Jan Baptista van Helmont (1580-1644), in a posthumous publication in 1662, wrote of taking 500 “poor people” with “fevers and pleurisies”, dividing them in half and casting lots for them. The two groups would be treated differently and the “numbers of funerals,” an absolute primary end-point, would determine the benefit or harm of venesection.

The first ever controlled trial may be even older. In 600BC Daniel of Judah asked for a 10 day trial of vegetables and water versus the king’s diet and asked the guard to decide which group looked healthier at the end of 10 days. The concepts of randomization and controlled trials are hence very old and the problem with knowledge translation, as noted with Lind’s discovery is also very old.

History can also highlight why changing clinical practice can be difficult. In 1846 Ignatz Semmelweiss attributed puerperal fever to an infection carried by obstetricians. Despite compelling evidence of mortality benefit (from 18% to 1.2%) by instituting simple measures such as washing hands, not routinely doing pelvic examinations and not attending wards rounds straight after attending the dissecting room, his findings were largely ignored. The problem with knowledge translation in this case was that Semmelweiss’ theories did not fit into the prevailing medical paradigm of the day, that of Galen’s humors. It would be another 30 years after Semmelweiss published his work that Pasteur’s germ theory of disease would become the new medical paradigm.

In the mid 1800’s Pierre Louis demonstrated venesection was not only ineffective but harmful. Venesection was such an expected practice that these findings too were ignored for many years, even by Louis himself.

These cases demonstrate that the principles underpinning randomised controlled trials (RCTs) and evidence-based medicine (EBM), principles such as randomisation, controls and meaningful primary end-points are quite old. They also demonstrate
that evidence can be difficult to get into clinical practice. The reasons why it is
difficult to get evidence into practice is explored further throughout this thesis.

More recently Archie Cochrane advocated that RCTs were more likely to provide
better evidence than that that gained from other sources. Sir Richard Doll
described that in the 1930s new treatments generally arose from consultants
observing effects of treatments in small numbers of their own patients, with no
control for confounders or bias\(^2\). The emphasis on RCTs as advocated by Cochrane
and the accessibility of information with the advent of the world wide web were key
components in the rise of EBM.

1.2 Rural Emergency Medicine

This thesis is about applying evidence-based medicine in rural emergency
departments (EDs) which by their nature provide a unique context. Emergency
departments in Australia provide primary care services across all spectrums of
severity and acuity and also act as the interface between primary and hospital
based healthcare. Emergency Departments are open 24 hours per day, are
multidisciplinary, are themselves a complex health system and are busy with 1.76
million attendances in NSW alone for the 2006/2007 financial year, increasing by
6.9\% annually.\(^9\) These figures only represent the 59 largest hospitals and do not
include presentations to the 100 or so small rural hospitals.

Emergency Department doctors cross the full spectrum of seniority from interns to
senior specialists, and from permanent to rotating to locum staff. In rural areas
smaller hospitals are generally staffed by general practitioner visiting medical
officers. Emergency medicine specialists in Australia provide direct patient care and
also supervise a large number of more junior doctors. In rural Australia this
extends to being a resource for medical staff in smaller rural towns. Hence
Emergency Physicians can not only provide appropriate evidence-based care to
their own patients but have the potential to influence others to also provide this
level of care. The capacity of senior specialists to influence the care of patients,
“within the system”, even those they never see, is thus a key component of this
thesis.

The seniority of ED nursing staff also varies from senior clinical nurse specialists
and nurse practitioners through to first year post-graduate nurses on rotation. In
larger EDs many nurses are dedicated to the ED but in smaller EDs nursing staff are
often covering the ED in conjunction with other nursing duties throughout the hospital.

### 1.3 Evidence-Based medicine

Evidence-Based medicine is 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."\(^{10}\)

The three key components of this definition are

1. It is applied to an individual patient
2. It relies on the best available evidence
3. It requires judiciousness or judgement to apply this evidence to the unique individual

My interest in EBM was fuelled by a clinical case over 10 years ago involving a patient who was unconscious from deliberate carbon monoxide (CO) poisoning. At that time hyperbaric oxygen (HBO) therapy was advocated for CO poisoning but was controversial. Subsequent to this I completed a systematic review of CO poisoning. The Cochrane database of systematic reviews is the world’s largest source of reviews and reviewers use a standardized methodology\(^{11}\) to make the review process as transparent and methodologically sound as possible. Whilst lacking the rigour of a Cochrane review, due to my own unfamiliarity with that process at that time and due to time and resource constraints, this review\(^{12}\) was published in Emergency Medicine Australasia with an accompanying editorial\(^{13}\) and subsequently letters to the editor.\(^{14,15}\) These articles are included in Appendix 1.

The CO poisoning review article included a systematic review of the role of HBO as a therapy. A subsequent Cochrane review\(^{16}\) included six studies, four of which were included in my review. The other two studies\(^{17,18}\) had not been published at the time, though one\(^{17}\) did have an interim analysis and this interim analysis\(^{19}\) was included in my review. The two reviews concurred, with the Cochrane analysis finding that “existing randomized trials do not establish (that) HBO...reduces the incidence of adverse neurological sequelae,” and that, “...further research is needed to define the role, if any, of HBO in the treatment of patients with carbon monoxide
poisoning.” Both reviews found that significant methodological and statistical heterogeneity made their conclusions difficult to interpret.

The relevance of the CO review to this thesis is that critical appraisal of clinical research findings is paramount to the understanding the quality of the evidence used in evidence-based medicine. In addition it highlights that “accepted practice” can be based on minimal or questionable evidence.

1.4 Thesis Aims

This thesis aims to determine if an evidence-based implementation (EBI) strategy can successfully implement a change in practice in the management of acute asthma in EDs. Furthermore, this thesis aims to determine if an EBI strategy can lead to greater changes in clinical care than more traditional or less targeted methods.

Literature reviews on the evidence supporting the management of acute asthma and on the evidence to support different implementation strategies were completed. A review of EBM, including its limitations, served as the template for the development of an EBI. This EBI was then used to implement changes in clinical practice in the ED. These changes were measured in controlled or “before and after” trials by developing key clinical indicators for the management of acute asthma.

The EBI included but was not limited to the implementation and adaptation of guidelines for the management of acute asthma. The World Health Organisation (WHO) recommends implementation of guidelines for asthma.20

1.5 Thesis Outline

The remainder of this thesis is presented as follows.

Chapter 2 Literature Review: Evidence-Based Treatment of Acute Asthma

Chapter 3 Literature Review: Developing an Evidence-Based Implementation

Chapter 4 Understanding EBM

Chapter 5 Presenting Evidence
Chapter 6  Evidence-Based Implementation

Chapter 7  Trials of Evidence-Based Implementation of Asthma Guidelines

Chapter 8  Audit in Quality Improvement Research

Chapter 9  Discussion

Chapter 2 contains a literature review of the evidence-base for the management of acute asthma. This literature review focussed on a review of the Cochrane database and the methodology used for the review is included in the chapter. Detailed knowledge of the evidence behind recommendations in the management of acute asthma is essential if one is to advocate for evidence-based asthma management.

Chapter 3 contains a literature review of the evidence base for implementing change in clinical practice with a particular focus on implementing guidelines.

Understanding of both these areas is essential for brokerage to occur between research findings and clinical practice, and formed the basis for the development of an evidence-based implementation, subsequently used in quantitative studies.

Chapter 4 presents two published papers. One paper highlights how EBM is an evolution of how medical knowledge is applied and not a revolution. The other discusses the benefits and limitations of EBM. This body of work introduces the concept of evidence-based implementation, a process analogous to EBM. This chapter also includes the associated editorial that these papers generated.

Chapter 5 presents two published papers. These articles condense extensive reviews of a topic into simple take home messages for clinicians. They are one way of translating knowledge, but as will be argued in Chapter 3, often more is needed. Papers such as these are not bedside tools. The article in the BMJ generated a number of rapid responses, these together with the replies are included in the chapter.

Chapter 6 presents one published paper and is the methodology of how the implementation strategies for the quantitative studies were developed. It introduces the concept of the “A4” guideline, a compacted version of the evidence for use by clinicians at the bedside.
Chapter 7 presents three published quantitative studies exploring the effectiveness of the implementation strategy.27,28,29

These papers studied the evidence-based implementation strategy in a variety of settings. A controlled trial of management of adult patients was conducted in ten rural district hospitals.27 These hospitals are staffed by general practitioner visiting medical officers, with no dedicated on-site medical staff and no dedicated ED nursing staff. A controlled trial in adults was conducted in larger rural referral and district hospitals with dedicated ED medical and nursing staff28. A before and after trial in paediatric patients was conducted in a large rural referral hospital29.

Chapter 8 presents one published study30 related to data collection in the paediatric paper29. This paper is quality improvement (QI) research, and auditing is an essential component of QI research. This research coincided with Children’s Emergency Care Project (CECP) – being run by the Clinical Excellence Commission (CEC) in NSW. The CECP aimed to implement clinical practice guidelines for 12 common or important paediatric conditions throughout NSW EDs. The CECP used baseline data from participating hospitals that were collected in the traditional audit method of retrospective chart review. During the CECP many sites changed their data collection method to a point of care teleform, completed by clinicians. This included a teleform for paediatric asthma. For consistency manual audit was used for all data sets in this thesis. For paediatric patients this resulted in two sets of data being collected and hence an opportunity to compare data collected by manual audit to data collected by teleform.

Chapter 9 is the discussion and discusses the process of developing an EBI and lessons that can be learnt from this thesis. It discusses the effects of the EBI on changing acute asthma management in the quantitative studies and importantly highlights the role of knowledge translation research if improvement in healthcare is to occur. The limitations of this thesis and future questions are also discussed in this section.

The Appendices follow Chapter 9.
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11. Cochrane handbook for systematic reviews of interventions 5.0.0 (Updated February 2008). Available at: www.cochrane.org/resources/handbook


Doherty SR. Prescribe systemic corticosteroids in acute asthma. BMJ 2009; 338:944:945


Doherty SR, Jones PD. Use of an “evidence-based implementation” strategy to implement evidence-based care of asthma into rural district hospital emergency departments. Rural Remote Health 2006;6(on line) 529. Available from URL: http://rrh.deakin.edu.au last accessed 20/10/2008


Chapter 2: Evidence-Based Treatment of Acute Asthma. A Review of Meta-analyses on the Cochrane Database

2.1 Introduction

Numerous treatment strategies exist for the management of acute asthma in adults and children. For many treatments meta-analyses have been completed both by the Cochrane collaboration and others. Results of these meta-analyses have led to the development of guidelines for the management of acute asthma for adults and children both in Australia and Internationally\(^1,2,3,4\). This paper reviews the Cochrane database of meta-analyses and summarises the treatment recommendations based on this. The Cochrane database of systematic reviews is the world’s largest source of reviews and reviewers use a standardized methodology\(^5\) to make the review process as transparent and methodologically sound as possible. Whilst there are limitations to evidence based medicine and limitations to meta-analyses, which are discussed further in section 2 of this thesis, the Cochrane database remains a reliable source of evidence.

2.2 Methods

The Cochrane database was searched using the search terms, “Acute Asthma treatment.” “Key words, title and abstracts” were searched. Relevant search finds in the Cochrane Database of systematic reviews and in the section “Other Reviews” were screened and those relevant to the management of acute asthma were selected.

Selected articles were read and evidence for effects noted and summarised under relevant topic headings in the discussion. Expanded search terms were then used to check for any missing articles and search terms “acute asthma” and “asthma” were searched for.

2.3 Results

For “acute asthma treatment” 45 articles were identified in the Cochrane database of systematic reviews and 17 other reviews were found. Of the 45 meta-analyses in the Cochrane database of reviews 19 were relevant to the treatment of acute
asthma, 13 related to other disease states, 8 related to chronic asthma management, 2 were protocols only and 3 related to aspects of care considered not relevant to the ED setting. Of the 17 other reviews 10 were considered relevant to the treatment of acute asthma, 5 related to publications based on a corresponding Cochrane review and 2 were provisional and unable to be viewed. Hence 29 meta-analyses were able to be reviewed, 19 from the Cochrane collaboration and 10 others. The expanded search terms identified 134 Cochrane and 61 other reviews when “asthma treatment“ was searched for in key words, title and abstract, and 189 Cochrane and 133 other reviews when “asthma“ was searched in keywords, title and abstract. These additional searches identified one further relevant Cochrane review and 3 other relevant reviews. A total of 20 Cochrane reviews and 13 others were suitable for inclusion.

A breakdown of the specific treatments that were subject to meta-analysis are shown in Table 1.

**Table 1: Meta-analyses on acute asthma treatments**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cochrane Reviews</th>
<th>Other Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salbutamol</td>
<td>Camargo et al 2003</td>
<td>Rodrigo 2002</td>
</tr>
<tr>
<td></td>
<td>Travers et al 2000</td>
<td></td>
</tr>
<tr>
<td>Anticholinergic agents</td>
<td>Plotnick et al 2000</td>
<td>Stoodley et al 1999</td>
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<td></td>
<td>Rodrigo et al 1999</td>
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<td></td>
<td></td>
<td>Rodrigo et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Osmond et al 1995</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>Smith et al 2003</td>
<td>Edmonds et al 2002</td>
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Date of Cochrane review is the date of most recent amendment.

**Beta-agonists**

Two Cochrane reviews\(^6,7\) and one other review\(^8\) have examined the role of beta2-agonists.

Camargo et al\(^6\) reviewed continuous versus intermittent nebulised Beta-agonists in acute asthma in the ED. Only RCTS were included and 8 trials were analysed (461 patients). Six of these trials were in adults, one in children and one mixed. Continuous, nebulised beta-agonists resulted in a reduction in hospital admissions (RR: 0.64; 95% CI:0.5-0.9) and the authors claim this was greater in severe airway obstruction (RR: 0.64; 95%CI:0.5-0.9). Continuous beta-agonists also resulted in small but statistically significant improvements in pulmonary function tests. The authors recommend continuous nebulised beta agonists in severe asthma.

Rodrigo and Rodrigo\(^8\) in a non-Cochrane systematic review of six RCTs in adults (n=393) found there was no difference in PFTs with intermittent versus continuous treatment with albuterol and no change in admission rates and concluded that the two regimes were equivalent. They cautioned against applying these findings in life threatening asthma.
Travers et al\textsuperscript{7} reviewed the role of IV beta2-agonists in acute severe asthma (which was widely and imprecisely defined across the studies) in the ED. Only RCTs were reviewed. 15 trials (12 exclusively adult) enrolling a total of 584 patients were included. They found that there was no benefit in PFTs with iv use versus inhalation and found no evidence to support iv beta2-agonists in acute severe asthma.

**Anticholinergics**

One Cochrane review\textsuperscript{9} and four other reviews\textsuperscript{10,11,12,13} have considered the role of anti-cholinergic agents in acute asthma.

Plotnick and Ducharme\textsuperscript{9} reviewed the effects of anticholinergic agents combined with beta2-agonists versus beta2-agonists alone in children. Thirteen RCTS including children aged 18 months to 17 years were included.

Overall they found that the addition of a single dose did not reduce hospital admission (RR: 0.93; 95% CI: 0.65-1.32) but did improve pulmonary function tests. If multiple doses were used they found that there was a significant decrease in hospital admission (RR: 0.75; 95% CI: 0.62-0.89) for children with moderate to severe exacerbations, giving a NNT of 12. If only children with severe exacerbations were considered, the NNT reduced to 7. The authors conclude that a single dose of anticholinergics is of no benefit in mild to moderate exacerbations but that multiple doses are of benefit and reduce hospital admission rates in severe exacerbations. The evidence they present recommends multiple doses in school aged children with severe exacerbations and found no evidence to support anticholinergics in other patient groups.

Osmond et al\textsuperscript{10} also reviewed the effect of ipratropium in acute childhood asthma and reviewed six randomised double blind controlled trials involving 285 children aged < 18 years. They found that whilst there was an improvement in pulmonary function tests there were no clinical benefits in terms of reduction of hospital admissions, length of admission or clinical rating scores.

Rodrigo and Casto-Rodriguez\textsuperscript{11} compared the effects of anticholinergics in children and adults when combined with beta2-agonists. They included 32 trials, 16 on children aged 5-months to 17-years (n=1998) and 16 on adults aged 18 or over (n=2047). 26 of the 32 trials were double blind. Most studies were on children with moderate to severe disease. The addition of anticholinergics reduced hospital
admissions in children and adolescents (RR: 0.73; 95% CI: 0.63-0.85) giving a NNT of 13 and also in adults (RR: 0.68; 95% CI: 0.53-0.86) giving a NNT of 14. Subgroup analysis found this benefit to be greatest in children and adults with severe exacerbations treated with multiple doses. Significant benefits in pulmonary function tests were also demonstrated especially with multiple doses.

Two other reviews have examined the effects of ipratropium in adults with acute asthma. Rodrigo et al\textsuperscript{12} reviewed 10 randomised double blind control trials involving 1483 patients (aged 17 or over) with moderate to severe asthma (based on respiratory function tests) and found significant benefits in pulmonary function tests and significant reductions in admission with ipratropium use in 5 trials that examined this outcome (RR: 0.62; 95% CI: 0.44-0.88).

Stoodley et al\textsuperscript{13} found similar benefits in reducing admission rates (3 RCTS with combination anticholinergic and beta2-agonists versus beta2-agonist alone) with a RR of 0.73 and 95% CI: 0.53-0.99. Again the greatest benefit was seen in those with most severe airway obstruction.

**Corticosteroids**

Six Cochrane reviews\textsuperscript{14,15,16,17,18,19} and one other\textsuperscript{20} have reviewed the role of corticosteroids in acute asthma.

Smith et al\textsuperscript{14} reviewed 7 RCTs involving 426 children aged 1-18 years hospitalised with acute severe asthma. No significant differences were found with Pulmonary function tests but a significant number of those who received steroids were discharged earlier (mean of 8.75 hours earlier) with NNT of 3. Furthermore they were less likely to relapse within 1-3 months (OR: 0.19; 95%CI: 0.07-0.55) with a NNT = 3.

Rowe et al\textsuperscript{15} reviewed the role of systemic corticosteroids in preventing relapse in adults and children discharged from the ED. Six RCTS involving 374 patients were included and those receiving steroids were less likely to relapse to require additional care in the first week (RR: 0.38; 95% CI: 0.2-0.74) an effect that was maintained for 21 days. There were fewer subsequent hospital admissions (RR 0.47; 95% CI 0.25 - 0.89) and less requirement for beta2-agonists, on average 3.3 less activations per day.
Rowe et al\textsuperscript{16} in another systematic review (12 trials including 863 patients) also found that early use (within one hour) of systemic corticosteroids decreased admission rates (OR: 0.40; 95% CI: 0.21-0.78) giving a NNT of 8. These results were more marked in those not on systemic corticosteroids prior to presentation.

Edmonds et al\textsuperscript{17} reviewed the role of inhaled corticosteroids in adults and children after discharge from the emergency department. Ten trials were included, three (909 patients) compared inhaled corticosteroids in addition to oral corticosteroids to oral corticosteroids alone. The other seven compared high dose inhaled corticosteroids to oral corticosteroids. This latter data was also reported separately\textsuperscript{20}. When inhaled corticosteroids were added to oral corticosteroids no additional benefit was demonstrated. Relapse was decreased but was not significant (OR 0.68; 95%CI: 0.46-1.02) and there was no difference in relapse requiring admission, quality of life, symptom scores or adverse effects. When high dose inhaled corticosteroids were compared to oral corticosteroids alone there was no significant difference in relapse rates, beta-agonist use, symptoms or adverse effects. The authors concluded that there is no evidence that inhaled corticosteroids provide additional benefit over and above oral corticosteroids and that there remains insufficient evidence that inhaled corticosteroids are as effective as oral corticosteroids.

Edmonds et al\textsuperscript{18} reviewed randomised or quasi-randomised trials of early inhaled corticosteroids in the emergency department. Ten trials of inhaled corticosteroids versus placebo, involving 587 adult and paediatric patients were reviewed and inhaled corticosteroids significantly decreased admission rates (OR 0.32; 95%CI: 0.18-0.54). A further seven trials (six paediatric) compared inhaled corticosteroids to oral corticosteroids (608 patients) with regard to admission rates only. Whilst there was no significant difference in admission rates (OR 0.66; 95% CI: 0.2 to 1.9) the authors recommend interpreting these results with caution because the heterogeneity of studies and wide confidence intervals.

Manser et al\textsuperscript{19} sought to determine if higher doses of CS either IV/IM/PO were more effective in hospitalised adults with acute asthma. Only six trials had sufficient data for meta-analysis. Higher doses conferred no benefit in % change of FEV1 or rates of respiratory failure. Low dose (defined as $<$80mg equivalent of methylprednisolone per day) appeared to be adequate in the initial management.
Magnesium Sulfate

Five meta-analyses, one exclusively paediatric, one exclusively adult and three mixed have conflicting results on the role of Magnesium sulphate.\textsuperscript{21,22,23,24,25}

Two Cochrane reviews involved both adult and paediatric patients. Rowe et al\textsuperscript{21} reviewed intravenous magnesium and Blitz et al\textsuperscript{22} reviewed inhaled magnesium, and both reviews found no evidence to support decreased hospital admission rates, despite modest improvement in PFTs and non-significant trends towards decreased admission rates. Rowe et al\textsuperscript{21} found a decrease in admission rates in the severe subgroup but insufficient evidence to support routine use whilst acknowledging it may be beneficial in severe cases.

Rodrigo et al\textsuperscript{23} found no beneficial effects in their meta-analysis of 5RCTs (374 patients) in moderate-severe adult asthma treated with intravenous or nebulised magnesium though Cheuk et al\textsuperscript{24} did find a benefit in moderate-severe paediatric group treated with intravenous magnesium with a reduction in need for admission (NNT = 4) but reported their results with caution because of the heterogeneity in the studies selected. Villeneuve et al\textsuperscript{25} reviewed six RCTs of predominantly adults (n=282) and found insufficient evidence to support nebulised magnesium sulphate.

Other Therapies

Two reviews, Ho et al\textsuperscript{26} (15 trials, 490 patients) and Rodrigo et al\textsuperscript{27} (10 trials, 544 patients) found no benefit for Heliox in the acute treatment of asthma.

There has only been one meta-analysis of aminophylline in acute severe asthma in children\textsuperscript{28}. This included seven RCTS comparing aminophylline to placebo in addition to usual treatment. Whilst there were improvements in FEV1 there was no effects on length of stay, symptoms, rate of ventilation or beta2-agonist use and there was a three-fold increase in vomiting. A meta-analysis of 15 RCTs in adults\textsuperscript{29} comparing aminophylline to placebo, in addition to usual treatments, found no significant effect on airflow obstruction but an increase in palpitations/arrhythmias (OR: 2.9; 95% CI: 1.5-5.7) and vomiting (OR: 4.2; 95% CI: 2.4-7.4)

Lau et al\textsuperscript{30} reviewed trials of ketamine in acute severe asthma (defined as PEFR < 40% after three doses of albuterol) but there was only one RCT and 5 case reports. There was limited evidence to support its use with non-significant improvements in
PFTs, respiratory rate, admission rates and symptoms as well as non-significant increases in side effects, mostly dysphoria and dizziness.

A lone review\textsuperscript{31} of antibiotics in acute asthma found only two trials (n = 97 patients) and found the role of antibiotics difficult to assess.

Only one RCT of NIV in patients with severe acute asthma was selected for review\textsuperscript{32} and it only involved 30 patients. It demonstrated improvements in hospitalisation rates and PFTs, but is too small to draw any conclusions from.

**Spacer v nebuliser**

Cates et al\textsuperscript{33} reviewed 25 RCTs in adults (n=614) and children (n= 2066) in the ED and community setting as well as six trials in adults (n=28) and children (n=213) in the in-patient setting. There was no significant difference between MDI with spacing devices and nebulisers with respect to improving PFTs and admission rates. In children there was a significant decrease in emergency department length of stay of about 0.47 hours (95% CI: -0.58 to -0.37). Meta-analyses by Amirav et al\textsuperscript{34} (children) and Al-Sallami et al\textsuperscript{35} (adults and children) also found no difference between the two modalities, though both these non-Cochrane meta-analyses have been criticised for the method of review.

**Other strategies**

There have been two reviews of educational interventions for asthma in the ED. Tapp et al\textsuperscript{36} reviewed 12 trials in adults (n = 1954) and found educational interventions decreased admission rates but did not decrease representations. Haby et al\textsuperscript{37} reviewed 8 trials (n = 1407) in children and found no effects on admission rates or representations.

A review of Indigenous health care workers\textsuperscript{38} found only 1 study assessing the impact of indigenous health care workers in children with asthma (n = 24) and was too small to draw conclusions from.

**2.4 Discussion**

This search strategy sought to identify all relevant meta-analyses on the Cochrane database pertaining to the treatment of acute severe asthma. Not surprisingly these meta-analyses are consistent with widely published guidelines\textsuperscript{1,2,3,4}. 
Whilst beta2-agonists remain the first line agent in acute bronchospasm in asthma the above meta-analyses would indicate that there is disagreement about the benefits or otherwise of continuous beta2-agonist use and no evidence to support intravenous use. These findings are clouded somewhat by the different means of determining severity of asthma used across the studies and the relatively fewer presentations of severe and life threatening asthma. Furthermore, the most recent review of the efficacy of intravenous salbutamol is from 2000 and an analysis of intravenous salbutamol in children in 2002 found that a single intravenous bolus given over 10 minutes may reduce the duration of severe attacks. This highlights two limitations of meta-analysis. Firstly they are thorough and take a lot of time and effort to complete and hence are not always current and secondly they may not necessarily reveal subgroups that may benefit.

Five reviews encompassing the adult and paediatric populations all demonstrate the efficaciousness of anticholinergics in improving pulmonary function tests. They all suggest that multiple doses of anticholinergics combined with beta2-agonists reduce admission rates in adults and school aged children with severe asthma, with little evidence to support their use in mild to moderate asthma.

There appears to be a clear benefit for systemic corticosteroid use for all patients presenting with acute asthma in terms of preventing admission, relapse rates and symptom duration. Inhaled corticosteroids have yet to be shown to confer additional benefit and whilst they may eventually be shown to be as efficacious as systemic corticosteroids there is insufficient evidence to recommend this at this stage.

There is insufficient evidence to recommend magnesium sulphate as a routine treatment in acute asthma but there is some evidence it may be of benefit if given intravenously in acute, severe asthma.

There is no evidence to support the routine use of heliox, aminophylline, antibiotics or ketamine in the treatment of acute asthma. Aminophylline was associated with a significant increase in side-effects. There is no evidence to guide use of NIV in acute severe asthma.

There appears to be no difference in efficacy of medications when they are delivered via spacer with MDI compared to nebulisers. There is limited data on the
effect of education strategies in the ED with conflicting results and only one small trial of the impact on an indigenous health care worker.

The process of searching for meta-analyses on the Cochrane database can establish an evidence base for effectiveness of various strategies which can then be applied to individual patients. The triad of EBM is best available evidence, applied to the individual patient and applied judiciously. Each component of this warrants discussion.

The best available evidence in many of the areas in this review has its limitations. Meta-analyses are plagued by varying quality of the reviews, selecting studies, the validity of the studies (garbage in and garbage out), heterogeneity of selection criteria, outcomes and statistical methods (apples and oranges) and publication bias (file drawer problem) though this latter problem may be less significant than often thought. As such the evidence for many interventions is the best available but not necessarily infallible.

Secondly the evidence needs to be applied to an individual patient. Whilst the evidence may suggest, for example, that there is no benefit routinely using intravenous beta-agonists and NIV in acute severe asthma, if the clinical situation is deteriorating and the patient is not responding to other measures a judicious clinician may well decide to trial them. A judicious clinician would hopefully realise too that the great danger of NIV in this setting is persisting with it once the need for invasive ventilation is clear. These examples highlight an important difference between clinical research and clinical practice. Clinical research is conducted to target specific questions, complexity and confounders are controlled partly by inclusion and exclusion criteria. Clinicians may well argue that clinical research occurs in an abstract and theoretical world which is different to the real world they practice in. This is compounded when surrogate outcomes are used to gauge the effect of a clinical intervention and clouded even more in meta-analysis when varying methodologies, outcome measures and results are aggregated. For a clinician the evidence still needs to be judiciously applied to the patient before them. Real patients have co-morbidities, or are older or younger than the inclusion criteria, may be on other medications and may have expectations of particular treatments. These are individual considerations and need to be taken into account when applying the evidence.
2.5 Conclusion

This study summarises the current meta-analyses available on the Cochrane database for the treatment of acute severe asthma. These meta-analyses are consistent with and underpin published guidelines.
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Chapter 3: Literature Review: Developing an Evidence-Based Implementation

3.1 Introduction

This chapter will first discuss broadly how evidence is developed to the point that it is known to have benefit for patients. The final step in this process, knowledge translation, can then be seen in its overall context. The remainder of the chapter will then focus on the literature that supports certain intervention strategies and how this can be used to develop an evidence-based implementation.

Much of this literature review is based on Master classes conducted by the National Institute of Clinical Studies – National Medical Health and Research Council during the period of a three-year research fellowship I held with them from March 2004 to March 2007. The Master classes involved international experts in implementing change in clinical practice presenting to the NICS fellows. Extensive pre-reading was provided for these workshops allowing a library of articles to be developed.

3.2 Knowledge Translation in Context

The use of evidence to guide clinical care and hence improve health outcomes is dependent on a number of components.

The process begins with new knowledge from basic biomedical research such as physiology and pharmacology. In the case of pharmaceuticals new agents go through a number of phases of clinical trials. Preclinical trials precede Phase I trials on humans, which are designed to look at the safety, tolerance, and pharmacokinetics of a new drug in healthy volunteers. Phase II trials study the efficacy of the drug in a larger group of patients whilst still monitoring the safety aspects of the drug. Phase III trials are often large, multicentre, randomised, controlled trials defined to provide definitive evidence of the effect (or lack of effect) of a particular treatment. Phase IV or post-marketing trials review the safety of the drug once it has been approved for use in the real world.

Knowledge translation does not form part of the phases of clinical trials. Knowledge translation as a concept comes in after high quality Phase III trials have demonstrated a benefit of a particular treatment. Knowledge translation itself does
not just happen and health services implementation research is that branch of research which looks at how better to implement change, it adds new knowledge to the "science" of changing practice. For knowledge translation to occur a number of steps need to occur. These steps involve awareness of the evidence, belief in the evidence and then applying it into clinical practice.

**Awareness**

For clinicians to use new knowledge or new treatments they need to be aware of the research demonstrating benefit. This may occur through publication of research studies, attendance at conferences where the information is presented or from dialogue with colleagues. In most research studies though the researcher is aiming to prove or disprove a hypothesis and present their data from that perspective, not from the perspective of making clinicians change their practice to incorporate these new methods. The research is primarily seeking to present new evidence and not address how this new evidence will be applied.

**Belief**

The clinician once aware of the data then needs to believe that the data will be applicable to their patients. This point is vital in understanding clinician attitudes to new therapies. An editorial by Wears in Annals of Emergency Medicine\(^1\) highlighted the disconnect between researchers and clinicians and asked why clinicians don’t pay attention to research and alluded to “good” research and “bad” clinicians. The author argued that it was as if clinicians were deliberately providing poor care to the point that agencies were now sending out researchers to find out why clinicians were “perverse, aberrant and irrational,” in their resistance to knowledge translation. Then in a change of tack the author argues that in fact clinicians should send out researchers to, “understand why...pockets of people...believe their abstractions are useful guides to a complex, messy world.”\(^1\)

What the author is demonstrating here is that researchers and clinicians operate under different paradigms and in different worlds. Researchers aim to answer a specific question in a specific context. Their paradigm is positivism and they conduct “clean”, empirical studies. They are the theoretical “knowers” and are largely inattentive to knowledge in action. If difficulties arise researchers simplify things by excluding certain groups and confounders. Often the process of clinical research is to perform empirical scientific studies that if repeated would
demonstrate the same results. Clinicians and patients however don’t live in this world they live in the real world with patients who have multiple co-morbidities, are on multiple medications and have their own beliefs about what should and should not be done. In the clinical world, especially in emergency departments, organisational processes, legislative requirements, fluctuations in workload, staffing shortages and many other things impact on the delivery of patient care. This is the “messy world” of knowledge in action. In this world clinicians are the “doers” and are wary of people from outside of their world telling them how they should be doing things. In this “real world,” evidence, no matter how good, may not be easy to apply because researchers do not necessarily understand the contexts and constraints under which clinicians provide care. This highlights the importance of brokerage in knowledge translation. In all likelihood both the researchers and clinicians are competent but each needs to understand the other if the two groups are to work more effectively together and brokers with knowledge and expertise across both sectors can facilitate this.²

As a digression this difference between clinicians and researchers also exists between clinicians and quality improvement departments and policy makers². Again policy makers and QI staff are generally not at the clinical frontline. They use research to form theoretical “best practice” and then expect that this “best practice” should be readily and easily embraced. It is, Wears would argue¹, “the rhetoric of colonial, imperialist masters seeking to bring a simplified version (of western civilisation) to childlike locals (who ungratefully don’t accept it).”

Hence from a clinical perspective, belief means not only belief that the research findings are accurate, but that the findings are relevant to the patient population the clinician sees and to the environment in which they work.

**Application**

Even if clinicians are aware of the knowledge and even if they believe it to be of use in their patient population, they need to be able to apply it. Application of knowledge may require specialist resources or equipment which are unavailable, for instance in a small rural hospital. More relevant to this thesis though is that application may require detailed knowledge of a particular condition. In the acute management of asthma there is abundant evidence for certain treatment strategies which vary depending on the severity of the presentation. To simplify this numerous clinical practice guidelines (CPGs) have been developed such as the NAC
handbook\textsuperscript{3} amongst many others. Whilst the NAC handbook is a thorough document it is also over 80 pages long and hence if maximum benefit is to be gained from this resource then it needs to be made easily accessible to busy clinicians. Simplification of these guidelines into a single page that could be incorporated into the medical record was a component of the intervention used in the clinical trials. This format meant the information was available at the bedside, was simple and easy to use, and was incorporated into the clinical record hence avoiding duplication. Examples of the guidelines are available in the papers presented in section 3.

There has traditionally been a greater emphasis on basic sciences research and conducting clinical trials than there has been on translating knowledge into clinical practice. The translation of knowledge from clinical trials to clinical practice has been cited as one of the major barriers preventing benefit from the biomedical sciences.\textsuperscript{4} This translational block contributes to a disconnect between the promise of basic scientific knowledge and better health outcomes. The other contributors to this disconnect are incomplete scientific knowledge, a translational block between laboratory findings and better ways to diagnose or treat and finally sufficient numbers of high quality clinical trials\textsuperscript{4}.

This Awareness – Belief – Application process has been described in various forms previously. Pathman et al\textsuperscript{5} have previously described the process of clinicians following clinical practice guidelines as following four steps. They initially need to be “aware” of the guidelines and intellectually “agree” with them. From this point they need to “adopt” them into their clinical practice and then regularly “adhere” to them, the so called Awareness-to-Adherence model.

Glasziou and Haynes\textsuperscript{6} have further refined this approach and developed the concept of the evidence pipeline. This model also commences with “Awareness” with difficulties finding recent, relevant evidence amid the myriad of publications every year a key obstacle at this stage. Acceptance is akin to intellectual agreement but may be influenced by factors other than independent, unbiased evidence such as marketing, advertising and peer validation. “Adoption” in Pathman’s model essentially becomes “Applicability” (is the evidence applicable to the individual patient), “Ability” (is the intervention able to be applied, is it available, are the skills and resources available) and “Acted on” in the Glasziou model. Finally “Adherence’ requires the patient to agree to proposed interventions or treatments and then to remain adherent to them.
Using evidence from the basic sciences to develop new knowledge and evidence from clinical trials that is then applied by clinicians for the benefit of patients only partly completes the spectrum of implementation. The benefit of applying knowledge may also dictate health policy, especially when the benefits are substantial.

The remainder of this chapter will discuss the development of an EBI strategy and the evidence that underpins this. It is focussed primarily at the point of clinical care, the point where the evidence is known but not necessarily applied.

### 3.3 Developing an Evidence Based Implementation Strategy

The translation of research evidence into clinical practice is difficult\(^7\) and some estimate that up to 40% of patients do not receive best available care and that 20% of treatments are not required or harmful\(^7\).

Changing clinical behaviour is possible when a well designed strategy is used, with average changes of about 10% in studies of guideline compliance.\(^7,8\) More research has been done on strategies directed at health professionals (eg education, reminders, audit and feedback) than for strategies aimed at patients, medical departments or health organizations\(^7\). There is evidence that passive implementation strategies such as the mailing out of guidelines or wall charts are of limited value.\(^9\)

Traditionally, many attempts at implementing changes in practice have been based on the beliefs of the investigator\(^10\), with no rationale provided for the choice of implementation method\(^8\). Whilst the evidence base for knowledge translation is incomplete, there is sufficient evidence to guide implementation strategies, leading some investigators to raise the concept of an evidence-based implementation (EBI)\(^8\).

### 3.4 Evidence based implementation

Evidence based medicine is a triad of best available evidence, judiciously used and applied to an individual patient.\(^11\) Evidence alone is not enough. The use of evidence to guide treatment is not a guarantee of success but predicts an effect on the balance of probability.\(^12\) In addition RCTs cannot always predict the suitability of any given treatment for an individual patient. RCTs have inclusion and exclusion
criteria and generally seek to gauge a treatment effect in a defined population sample. This population sample is not necessarily reflective of real patients seen in clinical practice who may have co-morbidities or “exclusion criteria” for the trials upon which the evidence is based. For this reason the other two components of EBM warrant further emphasis. The evidence, with its limitations must be used judiciously for any individual patient.

The definition of EBM can be applied in an analogous way to an evidence –based implementation. That is, an EBI is a triad of using best available evidence (of how to change clinical behaviour), judiciously used and applied to the individual unit, department or hospital in which you are trying to effect that change.

In the same way that a clinician uses their clinical judgement to act as a “broker” between the evidence and the individual patient, those involved with attempting to change clinician behaviour within a complex organization also have to use their knowledge to judge the likely impact of various strategies. In this sense the implementer acts as a “broker” between the evidence for implementing change and the department or unit that is being changed. This judgement requires the implementer to have knowledge not only of the evidence base for various strategies, but also of the planned implementation, the likely barriers and facilitators and a working knowledge of the staff, department and organizational processes. This broad ranging knowledge is required if effective judgement is to occur.

Importantly, evidence based medicine is ultimately applied to an individual patient and a clinician has to weigh up the unique characteristics of that individual before recommending strategies based on the best available evidence. In the EBI model the implementation will occur in a discrete unit or units and each unit (department, ward etc) is also unique. Strategies that work in one ward may not work in another. Intuitively this may especially be the case when there are more significant differences in the nature of the ward (eg an emergency department versus a rehabilitation ward) or in the size of the ward (eg a large tertiary hospital medical ward and a small rural medical ward). The unique characteristics of a ward or department need to be considered when implementation is being attempted.

This brings us back to the first part of the triad – the best available evidence. Numerous strategies have been attempted to try and change clinical practice. These have varied from passive strategies, such as mailing out guidelines to active
strategies such as medical detailing and audit and feedback. Implementation strategies have focused on single interventions and multi-faceted interventions. Given that most interventions can be successful in some circumstances but none are effective in all, a significant challenge to implementers is to gain an understanding of what interventions are most likely to be successful in their environment.

The remainder of this chapter will summarise the evidence-base for implementation.

3.5 Evidence for Implementation Strategies

Multi-faceted versus single factor strategies

Most studies of guideline implementation have focused on changing the behaviour of the individual, often with a single intervention, and have not focused on the practice environment. There is evidence though that focusing on individual clinicians will not be successful and that multifaceted strategies are required.

Experienced guideline implementers have identified the capacity of the organisation to change, the infrastructure for implementation, implementation strategies, medical group characteristics and characteristics of the guideline as important factors in achieving change. This group viewed implementation as being a complex process and favoured using multiple strategies. There is also evidence that organizational factors needed to be addressed.

In a practical sense, trying to change an individual practitioner will be more difficult if the focus is solely on that practitioner. Other staff members need to be involved. Where staff members form part of a healthcare team all team members need to be aware of the desired behaviour, the rationale and evidence supporting that behaviour, and set goals towards achieving it. Processes need to be addressed, so that if guidelines are to be used, the guidelines are available in a readily accessible and useable form when required. It may be that existing processes such as triage, or handover notes can act as triggers to remind clinicians of important changes in the way patients are to be managed.
Guideline Development and Usability

In some cases a key component of implementation is the development of “usable guidelines”. Guidelines can be considered as systematic statements to help clinicians and patients make decisions about care. A review in 2003 found that compliance with guidelines was better with:

1. type of health problem (compliance better for acute conditions)
2. better quality evidence
3. compatibility of recommendation with existing values
4. less complexity of decision making
5. fewer new skills needed
6. less organizational change
7. more concrete description of desired performance

Complexity of the guideline decreases compliance whilst trialability increases it. Guidelines are more likely to be used if the recommendations are clear, not controversial, do not require a change in practice and are evidence based.

There are now internationally recognized criteria, the AGREE criteria, which assess the components that should be considered when developing guidelines. These components include the scope and purpose of the guideline, the involvement of stakeholders, the rigour of the development of the guideline (both in terms of search strategies and quality of evidence), the clarity and presentation of the guideline, the applicability of the guideline and the editorial independence of the guideline developers.

If guidelines are used as an implementation strategy it clinicians are more likely to be responsive to guidelines that are from respected sources that they have an affiliation with.

Whilst the AGREE criteria do consider the implementation of the guideline the GLIA tool (Guideline Implementability Appraisal) looks more specifically at how easily a guideline may be implemented. Those involved with implementing guidelines to effect a change in clinical behaviour would do well to be familiar with these tools as
they allow the identification of possible barriers and facilitators to guideline implementation.22

**Guideline Implementation Strategies**

Guidelines are not self-implementing15 and a review of different guideline dissemination and implementation strategies has shed some light on what strategies are most likely to be beneficial8. Eighty-six percent of studies showed improvement in compliance with guidelines. There was a 10% improvement with guidelines across studies. Most dissemination and implementation strategies resulted in small to moderate improvements in care, 14.1% in 14 cluster RCTS of reminders, 8.1% in four RCTS of dissemination of educational material, 7% in five C-RCTS of audit and feedback and 6% in 13 C-RCTs of multifaceted interventions. There is also other evidence that reminders7,23 audit and feedback17,24 and outreach education25 are the three most effective strategies, even if the benefits are only modest.

However there are few descriptions of how to implement a reminder nor any studies of it14. Similarly there is little evidence about what form audit and feedback should take, who should perform it or how often.

There is more evidence for outreach education25 than passive dissemination of educational material,15,26 the latter of which has shown no statistically significant improvements in practice26 and is not thought sufficient to persuade people to change18.

The use of opinion leaders has some evidence to support it15,18,27 and intuitively this may be of greater value in a hospital setting where junior doctors are supervised by senior doctors. In some countries though peer review groups have developed specifically without interference of experts or so-called opinion leaders.28

**3.6 Identifying Barriers to Change**

Barriers to change need to be considered at the levels of the patient, individual clinician, the department team and the organization/processes of the department.29

Patients will have their own beliefs about treatments and what they require. A change in clinical practice or a change in their usual care, regardless of how evidence-based it is, may be met with resistance. Anecdotes and experiences of
friends and relatives will also help shape the views of patients. It is important that these issues be addressed, often through education and explanation, if implementation of better practice is to occur.

Individual clinicians may not want to use guidelines that recommend a best practice or an evidence-based practice.

Individuals may see EBM and guidelines as a challenge to the status quo, an increase in their workload and a questioning of their reputation as deliverers of best possible care. The problem facing an implementer may not so much be one of implementation but of defending EBM itself, or at least as it pertains to the guideline or change they are trying to implement. Others have no problem with the evidence but are worried about the proscriptiveness and medicolegal implications guidelines may have.

It is important that those seeking to implement change have a clear concept of what EBM is and what it isn’t. They need to have a clear understanding of limitations that clinicians may raise such as publication bias (the file drawer problem) and other limitations of meta-analysis, including different methodologies used in studies (comparing apples and oranges) and the inclusion of studies of various rigour (garbage in and garbage out). Even well conducted trials have inclusion and exclusion criteria and often don’t account for the vast array of comorbidities seen in clinical practice. Clinicians will rightly raise these objections to EBM and guidelines which makes it difficult to be too proscriptive about applying the evidence. These objections are all valid and it is important that implementers acknowledge that there are some things for which the evidence is compelling (eg early reperfusion in myocardial infarction) but other areas where there are grey zones and an array of seemingly different practices might all be appropriate once individual patient factors are taken into account.

At a more basic level an individual clinician level may have a lack of knowledge about new evidence or treatments, which is to be expected given that there are over 10 000 new clinical trials appearing on medline each year.

Health care often occurs in complex environments and within the setting of a healthcare team consisting not only of doctors, nurses and allied health therapists but also clerical staff. It is important for implementers to remember that a change in practice will probably require the effort of the whole team rather than just
targeting individuals. There is evidence that teams and departments are more likely to adopt changes into practice if they are involved in the project implementation plan from the outset. Team members need to be aware of the project and the need for change and implementation is more likely if those targeted have a sense of ownership over the project.

Any attempts to implement change in a complex health system will need to address the processes involved in that system. Patients are “processed” at many points by many people. Staff members have routines that are followed. Implementation can benefit if it is tied into the current processes that already exist. As an example in an emergency department setting all patients are triaged. If an implementation strategy involves the use of guidelines, automated pop-up screens on computer programs can serve to remind the triage nurse of the availability of guidelines. Knowledge of these processes facilitates the “judicious” aspect of the triad of EBI.

3.7 Summary

Implementing change is needed if knowledge translation is to improve. Implementation itself does have an evidence base and this evidence base can be used to as part of an EBI strategy. Aside from evidence the other cornerstones of EBI are judicious use of the evidence and its application to a specific unit or department.
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Chapter 4: Understanding Evidence-Based Medicine

This chapter presents two articles published in Emergency Medicine Australasia and an accompanying editorial.

These articles explore the definition of evidence-based medicine and trace the history of its evolution, so that together they place EBM in its context within health care. The articles also highlight the relationship between EBM and knowledge translation.

EBM has its limitations and can be difficult to practice, and the reasons for this are discussed in the articles. The level of evidence required is discussed not only from the perspective of what level of evidence is appropriate for any given scenario but also from the perspective of how existing evidence has arisen.

These articles were provided to clinicians in advance of meetings to discuss the proposed implementation studies and were also used in presentations promoting the use of the asthma guidelines. They were used to add some colourful stories to a potentially “dry” topic and as such to help foster interest in evidence-based care.

Like EBM, knowledge translation also has difficulties. These articles provide some background about the broader concept of changing clinician behaviour. The case for changing behaviour rests not only with the evidence and the level and quality of the evidence, but may also depend on the specific clinical condition, the individual practitioner, the health care team, the health system and the patient. All of these factors can influence clinical practice.
Evidence-based medicine: Arguments for and against

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Abstract

In this article I will discuss the various definitions of evidence-based medicine (EBM), and summarize the application, criticisms and limitations of EBM. The spectrum of evidence, from pathophysiologic inference to randomized controlled trials, will be presented as a mechanism for filtering bias with more rigorous evidence being required when bias is more likely. Although randomized controlled trials and meta-analyses are at the top of the evidence hierarchy, they are not always necessary, might not be the most appropriate forms of evidence for some clinical questions, and have their own limitation that need to be understood. Best available evidence, applied to individual patients, is the cornerstone of EBM. Although there are valid criticisms and limitations of EBM, if these are understood then the practice of EBM can provide guidance to the clinician and enhance patient care.

Key words: evidence, evidence-based medicine, meta-analysis, randomized controlled trial.

Introduction

The term evidence-based medicine (EBM) has been widely used in recent years and has drawn vigorous comments from both proponents and opponents. Despite its recent ascendancy the origins of EBM are very old and some people date the principles of EBM to the medical method of French physician, Pierre Louis, who discredited phlebotomy. In this article I will review some of the problems with the definition of EBM, discuss the different levels of evidence, demonstrate that EBM can be practiced at an individual as well as at an institutional level and review the limitations and criticisms of EBM.

Next, I will use historical examples, including Pierre Louis, to outline the difficulties of knowledge translation; that is, the process of getting evidence into clinical practice.

Evidence-based medicine is the use of best available evidence to guide clinical practice and this concept is unlikely to be controversial. Jamrozik asserts that patients would prefer their treatments based on best available evidence and most doctors would prefer using treatments that have good evidence to support their use.

Why then has EBM caused division within the medical community, with some opponents labelling the proponents as "apes in the game of health economics" and
EBM as being a "means to humble the doctor"? To start to answer this question I will look at the definition of EBM.

**Definition**

The term EBM has been defined numerous times. The most commonly cited definition for EBM is that by Sackett et al. who defined it as the "systematic, explicit, and judicious use of best evidence in making decisions about the care of individual patients". The authors of this definition go on to add that "the practice of evidence based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research".

Others argue that "...advocates of evidence-based medicine want clinicians and consumers to pay attention to the best findings from health care research that are both valid and ready for clinical application". Neither of these definitions should cause too much debate.

Both of these definitions refer to best available evidence and include the need for it to be applied to individual patients. Although they mention research, neither mentions the randomized controlled trial (RCT) nor meta-analysis that many people tend to be synonymous with EBM. Evidence can take many forms: Clinical observation, case reports, observational studies and RCT constitute a spectrum with progressive, but never complete, elimination of bias. In other cases pathophysiological inference from the basic sciences might provide sufficient certainty, without the need for experimental evidence, for example, giving oxygen to hypoxic patients is a good thing in most cases.

However, other definitions make it easier to understand why some doctors are wary of EBM. The EBM Working Group talk of a new paradigm for medical practice and state that EBM de-emphasizes intuition, unexplained clinical experience and pathophysiological rationale as sufficient grounds for clinical decision-making and stresses the examination of evidence from clinical research. They go on to add the need for clinicians to develop new skills of literature searching and application of formal rules to evaluate the medical literature. Such a definition might be seen to deviate not only from clinical judgement, but also from the pathophysiological model on which medicine is based. In addition, it asserts that doctors need new skills and implies that the "old way" was somehow inferior.

Many clinicians might not have a clear concept of EBM, but frequent criticisms include over-reliance on RCT, lack of guidelines and "cookbook" medicine, lack of regard for decisions derived from basic sciences and the use of EBM as a crutch. These criticisms will be discussed later.

The definition by Sackett is the most commonly cited although this too has its critics. Schon and Stasiow criticize this definition as "evasive" and argue that homeopaths would claim that they use evidence for their treatments and that they would use the best evidence available to them. If we accept this point then it is clear that we have to put Sackett's definition into a context: it has to be compatible with our current knowledge of basic and clinical sciences. Best evidence has to be compatible with our current constellation of scientific and medical beliefs. The problem with this occurs when there are significant problems with the basic sciences. Galen's humoral theory was the prevailing and intersect medical paradigm for thousands of years. In the next part of this series we will see how Luod, Semmelweis, Louis Pasteur and others had advancements in medical knowledge and care delayed by such erroneous basic sciences.

Another criticism of EBM is that many proponents have labelled it a paradigm shift. Schon and Stasiow argue that the common mistake is to confuse it with or confuse with the Galenic humors. The recent increase in experimental evidence is inferring but not replacing the knowledge gained from the basic sciences. Clinical experience and clinical reasoning. In addition, as others have noted, experimental designs were added to observational designs and have not replaced them. Schon argues that EBM is not necessarily new, which has gone before it and it cannot constitute a new paradigm.

Despite this, the EBM Working Group considers EBM to be a new paradigm and describe as "both old and the "new paradigm". Clinical experience, basic sciences and instinct are common to both. The major change in the "new paradigm" relates to the need to be able to understand the rules of interpreting data and to the need to be able to independently appraise the literature. I would argue that this is a natural progression brought on by the proliferation of medical publications and research, coupled with greater access to information with the development of information technology. The new paradigm is thus really just an evolution of
the old one. In addition, even if we take the narrow view of EBM as being about RCT then the hypotheses for these trials will inevitably come from our understanding of the basic sciences.

Evidence-based medicine and the basic sciences are co-dependent. If basic science can provide us confidence in the safety and efficacy of an intervention then a RCT would be superfluous, thus making a mockery of articles such as the systematic review of parachute use to prevent death and major trauma. In the parachute article the authors cite the lack of an RCT or meta-analysis of parachuting as a reason for parachute use and conclude that as with many interventions, the effectiveness of parachuting has not been subjected to rigorous evaluation using randomized controlled trials. In their discussion the authors state that, understanding the natural history of free fall is therefore imperative, which is precisely the point. Although an attempt at humour, the article clearly implies that EBM equates with RCT.

Another essential component of the definition of EBM is that the evidence must be applied to an individual patient. Most trials have exclusion criteria, sometimes exhaustive. These exclusion criteria might apply to the patient before us and, hence, the physician's knowledge of the basic sciences, the patient and the patient's wishes all need to be considered when deciding if any given trial result is applicable to an individual setting. Evidence from research is but one component of clinical decision-making and individual patient circumstances and patient preference are the other key components. I have argued that EBM is using the best available evidence in the treatment of individual patients. If evidence is not confined to RCT or meta-analyses, but that all available evidence should be considered. I have also argued that EBM has evolved in conjunction with the proliferation of medical research and developments in information technology. I will now consider the levels of evidence.

**Levels of evidence**

Having argued that EBM is not about RCT alone it is worth considering what constitutes evidence. There are a number of systems for classifying evidence and all give greater weight to the RCT and randomised trials as the least reliable source of evidence. As an example the Centre for Evidence-Based Medicine at Oxford University use the following levels of evidence (Table 1) and further definitions of these levels are available at their website.

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Description</th>
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<tbody>
<tr>
<td>a</td>
<td>Systematic review of RCT</td>
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<tr>
<td>b</td>
<td>Single RCT</td>
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<tr>
<td>c</td>
<td>All or most</td>
</tr>
<tr>
<td>d</td>
<td>Systematic review of cohort studies</td>
</tr>
<tr>
<td>e</td>
<td>Cohort study or poor RCT</td>
</tr>
<tr>
<td>f</td>
<td>Outcomes research</td>
</tr>
<tr>
<td>g</td>
<td>Systematic review of case-controlled studies</td>
</tr>
<tr>
<td>h</td>
<td>Case-control study</td>
</tr>
<tr>
<td>i</td>
<td>Case series</td>
</tr>
<tr>
<td>j</td>
<td>Expert opinion, physiology, bench research</td>
</tr>
</tbody>
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**RCT, randomized controlled trial.**

Others have summarised the hierarchy of evidence along the same principles but with different gradings, which are a variation of the Gey classification:

- Level I Evidence from meta-analysis or at least two RCT of high quality
- Level II Evidence from at least one RCT
- Level III Non-randomized studies
- Level IIIa Evidence from a non-randomized experiment
- Level IIIb Evidence from a cohort study
- Level IIIc Evidence from a case-control study
- Level IV Other observational studies, case series, etc.
- Level V Expert opinion

Any level of evidence might be sufficient depending on the clinical question of concern and the context of that question. With regards to parachute use when jumping out of aircraft, common sense, let alone the basic sciences, tell us that the use of parachutes will decrease death and injury. This 'evidence' from basic sciences or expert opinion is sufficient even if it is level V and for that particular question is as valid as a RCT might be for a different question. Green has suggested that one only need climb to the appropriate rung of the evidence ladder. He adds, 'RCTs aren't holy writ, they're simply a tool for filtering out our natural human biases ... whether it's necessary to use that tool depends upon the likelihood of that bias occurring'. There was no RCT for the introduction of insulin for diabetes mellitus in 1922, a universally fatal disease at the time, or for penicillin 30 years later. Their acceptance occurred after what we would now call a phase II clinical trial. After clear, obvious and life-saving effects in a small number of people these treatments rapidly became more widely used. It is unlikely that bias accounted for the life-saving effects of insulin in 1922 and the historical controls provide...
adequate evidence. This would constitute level IV evidence under the Gray classification (observational studies) and level IV is very low on the rung of the ladder, but sufficiently powerful and ethically acceptable for the given clinical setting.

For many treatments, especially where a small benefit is being sought, where there is a large natural variation in outcomes or where there is significant heterogeneity, the RCT has become the gold standard. However, if we are looking at diagnostic tests then we need to study patients with the disorder and a cross-sectional study is more appropriate. For prognostic information longitudinal studies are more appropriate. Rare conditions and events also do not lend themselves to RCT and case reports or case series might be the best available evidence.

The level of evidence needs to be appropriate for the clinical question and there is no need to climb to the top of the ladder when there is sufficient evidence lower down. Indeed, it might be inappropriate to conduct RCT for some clinical questions as illustrated above.

Individual and institutional evidence-based practice

Many will be familiar with the PICO (patient or population, intervention, comparator/control, outcome) model of evidence-based searching. This method allows individual clinicians to turn the requested information into an answerable question. To practise this one needs to be able to find, critically appraise and apply the evidence to the patient before him/her, preferably with speed and rigor.

The steps in this approach are:
1. Turn information requested into an answerable question by using PICO.
2. Locate the information in databases such as Cochran or from primary research.
3. Critically appraise the information.
4. Interpret the evidence and apply it to the specific patient.

An example of this approach has been provided by Elbridge and Smyth as follows:

* A 3-year-old child presents to the ED with croup. Are steroids beneficial?
  * Population: Children with croup
  * Intervention: Steroid therapy
  * Control: No steroid therapy
  * Outcome: Shorter symptom duration, admission rates, reduced intubation etc.

This approach leads to the question: In children with croup, is steroid therapy, compared with no steroid therapy, effective in reducing acute symptoms?

This can lead to a search on a database such as Cochran and the information applied to the individual patient. The PICO approach can be used by an individual doctor for a whole variety of clinical questions. Searching for the information, assessing the quality and applying that information to an individual patient all require skill and time, with limitations that will be discussed further in the next section.

At an institutional level most emergency physicians are involved in the practice of EBM through a variety of clinical guidelines and pathways that we not only use but also often develop. Few of us would question the benefit of thrombolitics or aspirin in ST segment elevation myocardial infarction. Many ED will have ‘chest pain’ pathways or be involved in collaborations such as ‘Towards a Safer Culture’. Many ED have asthma management guidelines, utilize antibiotic guidelines and promote the use of clinical decision rules in radiology. There are of course many other examples. These are all attempts at trying to get evidence into practice, a concept known as knowledge translation. The failure of knowledge translation has been cited as one of the two major barriers preventing benefit from biomedical research. In the next part of this series I will look at the barriers to knowledge translation in further detail.

Criticisms of evidence-based medicine

I have mentioned criticisms of the definition of EBM and the concept of a paradigm shift. There are many other criticisms of EBM and these will be briefly discussed. Jamrold groups opponents of EBM into four groups:

1. Constitutionally conservative. This group is uncomfortable with the challenge to the status quo and may feel threatened by an increase in their workload or questioning of their profession’s reputation as a deliverer of best possible care.
2. The skeptics. This group is wary of new fads but might be able to be persuaded with time by innovators and enthusiasts.
3. Already converted. This group consists of those already practising EBM and wonder why the point is being laboured.
4. Libertarians. This group has no great objection to EBM per se but worry where it is heading with the proliferation of guidelines and protocols. They are
concerned that administrators and lawyers might misuse EBM.

A summary of the major arguments against EBM that these groups might put forward is included below.

There is insufficient or no evidence

Opponents of EBM question the quality of the evidence. Publication bias results in negative trials being significantly less likely to be published than positive trials.\textsuperscript{52,53} and pharmaceutical industry-sponsored trials might also be published significantly more frequently.\textsuperscript{54}

Some are concerned that pharmaceutical companies are setting the research agenda.\textsuperscript{34} Criticisms of meta-analysis include the differing methodologies of the various studies (comparing apples and oranges), inclusion of studies of various quality (garbage in and garbage out) and, as mentioned above, publication bias (the file drawer problem).\textsuperscript{55,56} Others cite the problem with the research methods themselves that allow methodologically similar studies to produce contradictory results.\textsuperscript{57}

Apart from the scientific evidence itself, some argue that there is no evidence for EBM and there is unlikely to be any evidence that EBM leads to better care.\textsuperscript{58} In other cases good-quality evidence is lacking or not relevant.\textsuperscript{59}

These are all valid points although I would argue that there is evidence that EBM leads to better care. As an example, let us go back in time to the days before thrombolytic therapy for ST segment elevation myocardial infarction. At some point in time the evidence that thrombolysis improved morbidity and mortality became compelling. Furthermore, good evidence became available that earlier thrombolysis was better still. As a consequence thrombolytic therapy became a standard of care. Hospitals developed guidelines for the administration of thrombolytics, efforts were made to facilitate earlier thrombolysis and clinical guidelines were developed to monitor performance. This is EBM in action with a proven treatment being used and with guidelines and protocols facilitating knowledge translation.

It is not possible to practice evidence-based medicine

A common criticism of EBM is that it cannot be done. The argument is that busy clinicians do not have the time nor the skills to search, find and critically appraise the literature, for the whole myriad of problems they may encounter in a day,\textsuperscript{50,59} especially if it a half-day of clinical practice raises 16 clinically important questions to be searched.\textsuperscript{51} These are valid criticisms and impose on the ability of individual clinicians to practice EBM at the bedside. There have been attempts for external bodies to answer questions such as the now defunct \textit{EBM in action series}, published in the \textit{Medical Journal of Australia}. Guidelines and protocols are institutional methods to try and promote the use of good evidence, but these too are often criticized.

Evidence-based medicine is ‘cookbook’ medicine

Guidelines and protocols have raised criticisms of promoting cookbook medicine and suppressing clinical freedom.\textsuperscript{50} Like EBM, guidelines and protocols need to be applied to individual patients, for they are in reality just a mechanism for knowledge translation. Clinical guidelines have been developed for a whole range of conditions and their prime aim is to improve the quality of care. However, many guidelines are not used after dissemination\textsuperscript{50} and there are data available on what attributes of a guideline increase its likelihood of being used.\textsuperscript{50} Criticisms of guidelines are not so much a criticism of EBM itself, but are of this method of knowledge translation.

Evidence-based medicine subjugates doctors

The final and often most scathing criticism of EBM is that it is a means to serve cost-cutters and administrators;\textsuperscript{50} that it is following its own political agenda;\textsuperscript{50} and has created its own profitable industry.\textsuperscript{50} Is EBM a means to serve administrators or is it an attempt to improve care? Is EBM a means to serve administrators or is it an attempt to improve care? In a busy ED overwhelmed with junior staff, how do we ensure that an asthmatic patient has appropriate treatment prescribed? One approach is to use pre-defined algorithms to ensure that patients with myocardial infarction receive aspirin and thrombolysis within appropriate time frames. These are challenges and clinicians need to determine if they believe EBM is serving these patients or is it a means to control doctors and budgets.

Summary

For centuries mariners travelled the world with limited knowledge of their position at sea. Many ships were lost and many men died because of impr-
cine navigation. The longitude problem was a source of great concern to governments and many fine minds attempted to solve the problem. Galileo, by mapping the heavens, didn’t solve the longitude problem but did give sailors a better guide to their position at sea. Like Galileo’s astronomical charts EBM is not perfect and is open to criticism. Criticisms of EBM are all valid to some degree depending on one’s viewpoint. We need to be aware of the limitations of EBM. But if used wisely, like Galileo’s charts, EBM can be a useful guide to our own sea of uncertainty.

In this article, I have attempted to demonstrate that EBM incorporates many levels of evidence and that different levels of evidence are appropriate for different clinical questions. Once bound, the evidence has to be applied to an individual patient. I have attempted to refute the belief that EBM is synonymous with RCT, but rather is an evolutionary progression of knowledge based on the basic and clinical sciences and facilitated by the age of information technology. Finally, although there are obstacles, individual clinicians can practice EBM and there are also institutional attempts to facilitate the translation of evidence into practice.

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Competing interests

Associate Professor Steven Doherty is Section Editor, Peer Review of the Journal Emergency Medicine Australasia.

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History of evidence-based medicine. Oranges, chloride of lime and leeches: Barriers to teaching old dogs new tricks

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Abstract

Knowledge translation is the process of taking evidence from research and applying it in clinical practice. In this article I will cite some pivotal moments in the history of medicine to highlight the difficulties and delays associated with getting evidence into practice. These historical examples have much in common with modern medical trials and quality improvement processes. I will also review the reasons why evidence is not used and consider what factors facilitate the uptake of evidence. Understanding these concepts will make it easier for individual clinicians and institutions to change clinical behaviour and provide a starting point for those looking at implementing “new” practices, new therapies and clinical guidelines. Finally, I will offer a list of criteria that clinicians might choose to consider when deciding on whether or not to adopt a new practice, treatment or concept.

Key words: Evidence, evidence-based medicine, history of medicine, knowledge translation.

Introduction

A major challenge confronting healthcare today is to increase the uptake of the best available evidence into clinical practice, a process known as knowledge translation. The failure of knowledge translation has been cited as one of the two major barriers preventing benefit from biomedical research. In part one of this series I reviewed the definition of “evidence-based medicine” (EBM), and suggested that different levels of evidence are acceptable and appropriate depending on the clinical question and that EBM was not synonymous with randomized controlled trials (RCT). I concluded by introducing the concept of knowledge translation, which will be more fully discussed in this article.

There are numerous historical examples of good medical evidence not being utilized. This problem exists today, in spite of significant advances in information technology and the dissemination of information. For example, in spite of evidence for their benefit, angiotensin converting enzyme inhibitors are underprescribed in congestive heart failure.

Sir Richard Doll described the evidence for medical practice in London in the 1930s. As a junior doctor in 1937 Doll observed that new treatments invariably arose as a result of consultants observing the effects of...
treatments in small numbers of patients. Consultative
that had their own experience and case series to guide
them, but confounding variables and bias were not
taken into account. Some realized the limitations of this
method and proposed alternate patients receiving dif-
ferent treatment. This concept progressed slowly and
in an unblinded fashion.

In his experiment, Lind chose 12 men with symptom.
of scurvy whose cases were as similar as he could
have them. They all in general had painful gums, the
spots and lassitude with weakness of their knees. The
12 were divided into six pairs and each pair had differ-
ent additives to their usual diet. One pair had a quart
of cider each day, another pair 25 gr of starch (un-
specific diet) i.e., another pair half a quart of
water per day, another pair garlic, mustard and
houseards, another pair four of vinegar and
another pair two oranges and a lemon each, per day.
The citrus group only received treatment for 6 days, as
to this was all that could be spared, and the remaining
groups were treated for 14 days.

This study, although small, is randomized and con-
trolled. Efforts were made to limit confounders by
having cases as similar as could be found. There was a
specified treatment time and an outcome measure at
14 days.

The results of this study are shown in Table 1.
Lind noticed a dramatic recovery in the citrus group.
Even though the benefits of lime juice had been known
for centuries, Lind was able to demonstrate the super-
iority of citrus over other treatments. As he wrote, the
consequence was, that the most sudden and visible
good effects were perceived from the use of the oranges
and lemons, one of those who had taken them, being at
the end of six days fit for duty. The spots were not
indeed at that time quite off his body, nor his gums
sound... the other was the best recovered of any in his
condition; and being now deemed pretty well, was
appointed nurse to the rest of the sick.

These data were not published until 1764, 7 years
after the experiment, as a "Treatise on the Scurvy" and
it was another 46 years until the Admiralty added
lemon juice to ships. Although the benefits of lime juice
had been known, Lind had performed a RCT, albeit with
low numbers, and conclusively demonstrated the bene-
fit of citrus over other treatments. We will see later why
this finding took 50 years to be adopted.

Table 1. Lind's study on scurvy, 1747

<table>
<thead>
<tr>
<th>Additive to diet (6 = 2 in each group)</th>
<th>Observed effect</th>
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<tr>
<td>Quart of cider</td>
<td>Minor improvement</td>
</tr>
<tr>
<td>Unspecified diet</td>
<td>No change</td>
</tr>
<tr>
<td>Seawater</td>
<td>No change</td>
</tr>
<tr>
<td>Garlic, mustard and houseards</td>
<td>No change</td>
</tr>
<tr>
<td>Spoonful of vinegar</td>
<td>No change</td>
</tr>
<tr>
<td>Two oranges and a lemon</td>
<td>Dramatic recovery</td>
</tr>
</tbody>
</table>
One can debate whether this was the first ever controlled trial and we can go back as far as the Old Testament to find examples of controlled trials. In the Book of Daniel, Daniel asked his guard to compare the effects of a vegetarian diet (intervention) with the Royal Babylonian diet (control group). “Please allow your servants a ten days trial, during which we are given only vegetables to eat and water to drink. You can then compare our looks with those of the boys who eat the king’s food, go by what you see, and treat your servants accordingly.” The men agreed to do what they asked and put them on 10 days trial. When the 10 days were over they looked and were in better shape than any of the boys who had eaten their allowance from the royal table.

The concept of randomization was also at least 100 years old by the time of Lind’s trial. In a posthumous publication in 1862, Jan Baptista van Helmont (1580-1644), the “father” of biochemistry, wrote: “Let us take out of the camps, or from elsewhere, 200 or 300 poor people, that have fevers, pleurisy, etc. Let us divide them into half, let us use less, that one half of them may fall in my share, and the other to yours. I will cure them without bloodletting and sensible evacuation, but you do as you know. We shall see how many terrains both of us shall have.” As Jenner notes, this is not only an example of randomization but there is also a clearly defined and absolute end point.

**Chloride of lime**

Oliver Wendell Holmes (1809-1894) first recognized the contagious nature of puerperal fever, but it was Ignatz Semmelweis (1818-1865) who built on his work. In 1846, Semmelweis attributed puerperal fever to an infection carried by obstetricians. Despite reducing maternal mortality from 18% to 12% by hand-washing, his findings were rejected by the medical society of Vienna.

In Semmelweis’ time, Vienna maternity hospital was the largest in the world. From 1839 to 1847 patients were allocated to the midwives clinic and the doctors clinic on alternate days. In this period the death rate from (nearly exclusively) puerperal fever was 192.2 per 1000 births in the doctors clinic and 33.8 per 1000 births in the midwives clinic (Table 2). Medical students and doctors started their day with post-mortems before attending rounds where they routinely performed vaginal examinations as part of their training. The midwives performed neither of these practices. Semmelweis postulated that they carried “decomposing animal matter” and instead hand-washed in chloride of lime before entering the maternity ward. The mortality rate in 1846 fell to 12.7 per 1000 in the medical clinic and 1.3% in the midwives clinic. The process of alternate allocation made this a controlled trial and large numbers minimized the chance of bias. Mortality rates and characteristics of the obstetric clinics are shown in Table 2, which is an adaptation of the work by Louton.

Table 2 demonstrates that the mortality rates were relatively low until routine post-mortems were introduced. With the introduction of post-mortems there was an approximately fivefold increase in maternal mortality. The separation of the clinics into a doctor/midwife student clinic and a midwives clinic demonstrated that the mortality was excessive in the doctors’ clinic. It is also worth noting that in 1848 after the introduction of hand-washing the mortality rate fell to 12.7 per 1000 births, the same rate as before post-mortems were introduced.

For the period 1849-1857 the mortality rate went back up and this illustrates a problem with quality improvement programmes even today, even if behaviour can be changed it is difficult to maintain the change over time.

The Medical Society of Vienna, including such luminaries as Virchow, rejected Semmelweis' findings and they were rejected again when published in 1861. In that

<table>
<thead>
<tr>
<th>Period</th>
<th>Characteristics of period</th>
<th>No. deliveries</th>
<th>No. maternal deaths</th>
<th>Maternal deaths/1000 deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1834-1835</td>
<td>Routine post-mortems</td>
<td>71 305</td>
<td>327</td>
<td>12.5</td>
</tr>
<tr>
<td>1836-1838</td>
<td>Routine post-mortems</td>
<td>65 005</td>
<td>375</td>
<td>6.4</td>
</tr>
<tr>
<td>1838-1847</td>
<td>Clinic arrangements changed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First clinic doctors and students</td>
<td>32 931</td>
<td>1939</td>
<td>60.2</td>
</tr>
<tr>
<td></td>
<td>Second clinic midwives</td>
<td>21 726</td>
<td>925</td>
<td>42.8</td>
</tr>
<tr>
<td>1848-1850</td>
<td>Hand-washing introduced</td>
<td>47 305</td>
<td>1712</td>
<td>35.7</td>
</tr>
<tr>
<td></td>
<td>First clinic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second clinic</td>
<td>40 770</td>
<td>228</td>
<td>5.6</td>
</tr>
</tbody>
</table>
same year Louis Pasteur published his ‘Germs Theory of Disease’ after demonstrating that microorganisms, first observed by Anton van Leeuwenhoek, could be grown in broths. Seven years earlier John Snow had studied cholera and helped minimize the disease by removing the handle from the Broad Street pump. Snow had also postulated that cholera was a living organism that multiplied in the intestine. Despite the work of Semmelweis and Snow among others it would be another 30 years before Pasteur’s theory was widely accepted.

Leeches

Some authors cite the principles of EBM to Pierre Louis, who in the mid-1800s, developed a numerical method and demonstrated that bloodletting for pneumonia was of no benefit. Louis’ numerical method and ‘method of observation’ as it related to pneumonia, was a retrospective analysis of what today would be defined as a case series. Louis used columns listing duration of symptoms, early (≤4 days) bleeding or late bleeding and death or survival. His findings were reported in his 1859 monograph ‘Recherches sur les effets de la sanguinée’ (Research on the effects of bloodletting).

Historical data can be seen today and are summarized in Table 3. Louis has been linked for his contribution to epidemiology and has even had his data confirmed by modern analysis.

The duration of symptoms ranged from 4 to 62 days. As can be seen in Table 3, the absolute risk reduction with late phlebotomy was 18%. His discoveries were largely ignored and his adverse findings against phlebotomy were not readily adopted. As with Lind and Semmelweis, there was a significant delay in getting evidence into practice.

Barriers to teaching old dog new tricks

Lind, Semmelweis and Louis all demonstrated clear evidence for an effective therapy; a preventative measure and the abandonment of an ineffective treatment, respectively. In each case their evidence was rejected for many years and patients continued to be denied effective treatments or to receive ineffective treatments. There is evidence that such practice continues today with studies suggesting that up to 25% of patients receive harmful treatments and up to 60% do not receive treatments that are known to be effective.

There are many reasons why good evidence is not readily adopted into clinical practice. These can be summarized as follows:

- Characteristics of the evidence itself
- Barriers or resistance to the uptake of the evidence
  - This can occur at the level of the patient, the practitioner, health-care team, institution or wider environment
  - Ineffective transfer of evidence into practice (knowledge translation)

The published literature on this is extensive and beyond the scope of this article, but some features will be outlined below.

Knowledge translation has become more difficult because of the ever-expanding amount of knowledge gained from clinical trials. From 1973 to 1987, there has been a 17-fold increase in the number of randomized studies published per year, with over a 100-fold increase in the number of meta-analyses and clinical guidelines published on Medline and there are more than 10,000 new randomized trials added to Medline each year. Such vast amounts of research and guideline proliferation make it difficult for clinicians to use the available evidence at all times and require them to develop search and access skills. Most clinicians do not have time for this and traditional approaches have included making information more accessible by repackaging it in guidelines or as review articles or as continuing medical education activity or for presentation at scientific meetings. However, to change practice often, more than this is required.

The characteristics of the evidence or change itself can have a bearing on whether evidence is taken up into practice. If the change is easy, such as eating oranges or washing hands, then it is potentially easier to change practice. If the change is more complex or requires better collaboration or organizational changes then it is harder to adopt.

Other facilitators to the uptake of evidence include:

- Type of health problem (acute taken up more readily than chronic)
- Better quality evidence
- Compatibility of recommendation with existing values
- Less complexity of decision-making
- Fewer new skills needed
- Less organisational change

To this list some would add that the change needs to be perceived to be better, that the change is able to be tried first and that it will have observable benefits to others.29

The compatibility with existing values is one of the main reasons why the work of Lind, Semmelweis, Louis Pasteur was rejected. At the time of their work the prevailing medical paradigm was that of Galen's humours and the concept of disease as a result of miasma, living organisms was considered sinful.

Donat and Del Mar28 postulate that doctors used treatments that do not work for the following reason:

- Their own clinical experience
- Over reliance on a surrogate outcome
- Natural history of the illness
- Love of a wrong pathophysiological model
- Ritual and mystique
- A need to do something
- No one asks the question
- Patients’ expectations (real or assumed)

They go on to add that the same criteria can be applied to unnecessary pathology testing and redundant clinical examination techniques and argue that societal values are such that errors of omission are worse than errors of commission.

If we apply these criteria to our historical examples, we could argue that some of them help explain why ineffective treatments for scurvy and pneumonia continued in spite of contrary evidence to their effectiveness. The individual clinical experiences of doctors with phlebotomy was that many of their patients did recover, possibly as a result of the natural history of the disease. Unlike bioterrorism, vitamin C for scurvy and the concept of germs causing septic infections did not fit with the medical paradigm of the day and Galen’s humoral model for disease was not only firmly believed but also wrong. We could well argue too that phlebotomy and unspecified elixirs carried with them a certain mystique that patients had expected, and we can all identify with the feeling of needing to do something.

As an extension of this topic, it might be worthwhile as an individual practitioner to consider the following five criteria when assessing new interventions. These criteria can be considered when adopting or abandoning a medical intervention and may apply not only to new treatments (or old treatments) but also new investigation techniques and even new concepts such as EBRM. It can equally be applied to diagnostic or therapeutic interventions at the bedside. These criteria can be considered an aid to keeping our minds open to new ideas, yet questioning, and help us find a balance between blindly accepting information provided to us and closing our minds too early that which we know.

Five criteria for assessing interventions

What does the evidence say and is it applicable to the patient before us?

It is important when deciding to implement a new drug or diagnostic test to determine if there is:

1. Evidence that it works
2. Evidence that it doesn’t work, or
3. Evidence that it causes harm

The strength and appropriateness of the evidence also needs to be considered. For instance, the evidence that aspirin is a beneficial treatment in acute myocardial infarction27 is very strong and based on a large number of trials. With regard to levels of evidence we also need to consider the circumstances in which the evidence arises. For instance, as noted in the first article of this series, the introduction of insulin for diabetes melitus in 1922 was what we would now call a phase II clinical trial.4 Diabetes melitus at the time was a uniformly fatal disease and the impact of insulin as a treatment was so obvious after a small number of cases that its use became widespread. This would constitute level IV evidence, but one can readily accept this level of evidence if the context of its development and the effects of the disease are understood.

If this question had been asked with Lind, Semmelweis and Louis then citrus, hand-washing and ceasing phlebotomy might all have been adopted much earlier.

Evidence might come from many sources and if we are using evidence from a RCT or meta-analysis we need to remember that RCT have exclusion criteria and other limitations. Is the evidence we are using from a patient population applicable to the individual patient before us?

Does it fit in with our current paradigm?

When we appraise any evidence we need to consider if it is in keeping with our current understanding of patho-
physiology. Does it fit with our current scientific knowledge? Is it in keeping with our current ethical standards and societal values? What do the current opinion leaders say? These are important considerations and our medical paradigm prevents alternative medicine practitioners from practising EBM. They may practice evidence-based alternative medicine in keeping with their paradigm, but not EBM. Our historical examples above show us the limitations of our current paradigm. Galen's humoural theories were wrong, but they had enormous influence over the medical practice of the day. Luminaries and opinion leaders such as Virchow décribled Semmelweis for his 'impractical theorizing' over peripatal fever. Vucicanic, Fortunatus, Plenius, Professor of Medicine at the University of Louvain in 1653 not only vilified William Harvey for his discovery of the circulation of the blood, but also attempted to discredit 'Peruvian bark' or cinchona for the treatment of the ague (malaria) as it was not in keeping with the teachings of Hippocrates or Galen. We feel most comfortable with things that are consonant with what we know, but need to be aware that our scientific knowledge of medicine will continue to evolve, although maybe not as dramatically as the shift from the humours to the germ theory.

Is it easy to apply?

The two main considerations here are whether the intervention is feasible and whether it is expensive.

The Cochrane collaboration asserts that primary angioplasty is more effective than thrombolysis for ST segment elevation myocardial infarction with lower short-term (but not long-term) deaths, less reinfarction, less recurrent ischaemia and less strokes. This was based on meta-analysis of 10 studies including 2573 patients. They note that the most recent and the biggest trial involved general and highly specialized centres and was less favourable. They summarize by saying that angioplasty provides a short-term clinical advantage, which may not be sustained and that thrombolytic therapy remains an excellent strategy. (The Cochrane trial cited was withdrawn on 25 February 2004 as it was out of date and the topic is subject to a new review that was not available at the time of publication.)

If decision-makers were to decide that all patients with ST segment elevation myocardial infarction should receive angioplasty then this would clearly be a difficult intervention in the Australian healthcare setting. With only a small number of specialized centres performing angioplasty there would be large numbers of transfers between metropolitan hospitals without even considering the logistics of rural patients. To implement such an intervention would require multiple, complex and expensive changes.

In terms of cost, the introduction of activated protein C for severe sepsis has caused considerable debate. The randomized, double-blind, placebo-controlled multicentre trial that demonstrated a benefit for activated protein C appears to provide good evidence for its use. The cost of this treatment was about $65,000 per patient and 17 patients needed to be treated to save one life. However, this study had exhaustive exclusion criteria and a number of other limitations that will be discussed below.

With our historical examples, eating citrus fruits, washing hands and not using phlebotomy were not only cheap but also easy to introduce.

Who is pushing for change and why has it arisen?

It is useful to consider who is pushing the change and what is in it for them. Advertising and post-marketing evidence from pharmaceutical companies should always lead us to question the independence of the information. Pharmaceutical companies invest heavily in research and development of their products and have a vested interest in their products being supported by evidence. Some are concerned that pharmaceutical companies are setting the research agenda and that there is bias and selective publishing of pharmaceutical sponsored trials.

If we return to the activated protein C example, there are several issues worth highlighting. In the trial by the PROWESS study group, none of the investigators were employees of Eli Lilly, two were stockholders in Eli Lilly and five, including the principal author, have worked as consultants for Eli Lilly. Eli Lilly was the sponsor of the trial and the manufacturer of the drug. If we consider that the randomized, double-blind, controlled trial is at one end of the evidence spectrum and is the best filter at removing bias, then I would contend that drug company-sponsored trials performed by clinicians with a financial interest in the product introduce a new bias of their own. Patients were enrolled in the trial from July 1998 to June 2000. Several authors have highlighted changes in the study that occurred in and after June 1999 after 720 patients (of a total of 1690) had been enrolled. These changes are not contained in the original paper. The changes include:

- A change in the exclusion criteria favouring a less severely ill and more acute infectious illness group
• A new placebo (0.1% albumin as opposed to normal saline)
• Elimination of protein C deficiency as a primary variable for the analysis
• In August 1996 the master cell line for the manufacture of activated protein C was changed.

A Food and Drug Administration analysis revealed that the efficacy of activated protein C changed substantially after the change in protocol. Up to the change in protocol there was no difference in mortality in the treatment or placebo groups.

It is not only multinational pharmaceutical companies that can push for change. The introduction of meningococcal vaccination for Australian children was both political and emotive, after a number of well-publicised cases of the tragic outcomes that this disease can produce. This gave the introduction of meningococcal vaccination a significant advantage over the introduction of pneumococcal vaccination, even though the latter is a more common problem.

We can also apply this question to changes in health policy and even concepts like EBM. Who is pushing it and why? Is it, as Graham-Smith asserts, administrators trying to 'blackmail doctors and bend them to their will' in order to make them more cost-effective, or is it the medical community trying to improve patient care?

Is it distracting us from more important issues?

I was recently involved in a scenario of a head-injured patient in a rural area who had a significant delay in care. A road transfer to the nearest hospital with anaesthetic capabilities was not utilised because a paramedic-staffed helicopter was en route to the scene. As a consequence, a combative patient with a closed head injury was sedated with midazolam and transported by helicopter to the nearest base hospital. This patient required airway management and assessment of his closed head injury and the start of this care was delayed for several hours because an intervention, an aeromedical capacity, distracted us from the more important issue, of getting the patient to a doctor capable of providing initial definitive care in this case airway control in the most expedient fashion.

There are many other examples in everyday practice of interventions distracting us from more important issues. Inappropriate treatment of terminal illnesses detracts clinicians away from the most important issue of end of life care while cell counts in patients with suspected appendicitis can delay the most important issue of the need for laparotomy; X-ray radiographs for suspected fractures can lead us to overlook the need for analgesia.

When considering any intervention or treatment, be it as a general concept or for an individual patient, we need to consider if it is going to distract us from more pressing issues.

Summary

Difficulty in getting evidence integrated into everyday practice is not new and knowledge translation remains a challenge. The historical examples used in this article not only are famous episodes in the history of medicine, but also provide a good framework for highlighting the difficulties of knowledge translation. Clinicians would do well to reflect on what it is that shapes their clinical practice and to critically analyse why they do what they do. Changing behaviour is a complex issue both at the individual and the institutional level. At the individual level, reflection on why we do what we do, by considering the criteria outlined, might give individual clinicians some insight into their clinical decision making.

Acknowledgements

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Competing interests

Associate Professor Steven Dobert is Section Editor, Peer Review, of the Journal Emergency Medicine Australasia.

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Evidence-based practice: Where next? What, now?

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Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Queensland, Australia

See also pp. 307-40

This focus on evidence-based practice (EBP) for the Journal is timely and welcome. Four original papers take us on various journeys. The philosophical concerns with evidence-based medicine (EBM) show how it has the propensity to polarize clinicians, some finding it too constraining, others liberating; some worry about handing over the control to administrators, for whom EBM might be seen as a measure of quality, or even (though) insufficiently parsimonious care, and asks whether we should be embracing it all in the EBM. The answer, by the way, is yes. An entertaining trip down history lane shows it arose mostly over intervention questions with the emergence of the randomized controlled trial. A paper on diagnosis is welcome, with a careful dissection of standard characteristics of leukaemic-pseudomyeloma embolus. Understanding the clinical epidemiology of diagnostic tests is counter-intuitive and difficult; and I suspect many readers will find this paper by Chu and Brown tough. But it is important. The Cochrane Collaboration, which has dedicated itself for its first 30 years of existence to addressing intervention questions, resolved a couple of years ago to take on diagnostic questions too, although methods of meta-analysing the studies have yet to be refined. Finally, a series of case examples show how EBP can add another dimension of interest to our clinical practice, providing a way even of challenging the most superstitious physician accepting our patient. Those who hated EBP would just go away are disappointed. It is here, has entered the lexicon, and is embedded in clinical culture. It is hard to imagine anyone adopting an alternative stance now. You mean you would prefer to practice without using the best available evidence when making clinical decisions? Mmmm. And yet the status quo is disappointing. That emergency physicians are reading manuscripts in this Journal and finding it necessary to start off justifying EBM as a symptom. The truth is that we have not found a way to use EBP as an everyday — or better, every patient — function, like ordering tests or imaging on our patients. Were EBP really established like any other clinical activity designed to assist in making a clinical decision, such as say haematology, or radiology, then why is it used so little? It should be cheap, informative and educational. For example, the series of four illustrative cases come from at least two continents, over at least 4 years, and from someone who worked at one of the EBM worldwide Meccas (Oxford, England). In an ideal world we should each of us have a series of such anecdotes every day.

There are data from both community and hospital practice to show that clinicians have several questions per patient. The vast majority are never answered. The main reason is probably that EBP is too difficult. Yes, there are others: not enough time; too much to do; force of habit; role models that remain unacquainted; yet alone convinced, with the need to change insufficient rewards and threats to the status quo. EBP is an arena that a cat can look at a long, challenging his dearly held erroneous views so swiftly — is it perhaps why EBU attracts the more anaesthetists? Some consider that asking clinicians to learn the steps of EBP is too difficult (Table 1).

What are the alternatives? The most obvious is to abrogate the tasks. Guidelines are especially appropriate in some specialties such as emergency medicine.
Table 1. The four ‘A’s: Skills needed for EBP

<table>
<thead>
<tr>
<th>Skill</th>
<th>What is needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking</td>
<td>Turning the clinical question into a format that allows the question to be answered</td>
</tr>
<tr>
<td>2. Accessing</td>
<td>Searching the appropriate elements or print databases for the information missing, noting importance, yet being able to cope with the information overload</td>
</tr>
<tr>
<td>3. Appraising</td>
<td>Deciding which is the best of the evidence found, and whether its quality is usable. (This is really clinical epidemiology)</td>
</tr>
<tr>
<td>4. Applying</td>
<td>Deciding how to use the best evidence to help the patient</td>
</tr>
</tbody>
</table>

EBP, evidence-based practice

where many presentations are so urgent that there is no time to check for information. But guidelines have their problems: they are often contradictory; there are so many of them that searching them becomes a problem: they have no common format to make extracting the necessary information easy; and are difficult to keep up to date and adapt to individual patient preferences and variations. Sometimes they are not evidence based! It is against guidelines that so much of the profession rails, and the final criticism is that few follow them.

Another option is the use of literature search services, either jobbed out to librarians or special outside services. These have worked in some areas, and one of the papers mentioned TRIP, one of the most popular in the UK. Another worked well here in Australia for primary care. The problem with these services is that they are used for so few problems. Clinicians often fall at the first fence: how to formulate a question in the first place.

Whatever we do, whether abstraction, or doing the work ourselves either solo or in some sort of club within our clinical practice area, it remains important that we know enough of the processes of EBP to understand its limitations and benefits. It could come to replace much of continuing medical education, that hopelessly unproductive and expensive operation. We are vulnerable if we simply leave the mastery of clinical information to administrators and lawyers.

Competing interests

None declared.

References

Chapter 5: Presenting Evidence

This chapter presents two articles. One article is from the NICS-NHMRC Evidence into Practice series published on-line in 2006 and the other is from the British Medical Journal Change Page section published in 2009. In addition the rapid responses and replies to the British Medical Journal publication are included.

The primary papers are examples of concisely presenting evidence to clinicians and involve providing clear instructions of best practice and a summary of the evidence supporting that practice.

The rapid responses to the change page articles provide insight into how clinicians view and use evidence. The response by Theilhaber1 questions the role of systemic corticosteroids in viral-induced wheeze in children. He cites a paper by Martinez2 published in 1995 that differentiates pre-school asthma into viral-induced and multi-trigger asthma and also a study by Panickar et al3 which suggests that corticosteroids have no role to play in viral-induced asthma in this age group.

Theilhaber’s letter highlights the difficulties with getting evidence into practice. The paper by Panickar et al3 is a well conducted trial comparing oral steroids to placebo in acute viral-induced asthma in children aged 10 months to 5 years. The primary endpoint is time to discharge, with 5 hours being deemed a significant time difference. For a power of >80% with a two-sided alpha level of 0.05 two groups of 350 children were required. The groups fell short of this by seven (treatment group) and six (placebo group). The prednisone group had a shorter duration of stay (11 v 13.9 hours) but this failed to reach significance. Panickar et al3 discuss the limitations of their paper but for this thesis issues around accessing evidence warrant mentioning. Theilhaber1 notes that it took six months for the Change Page paper to be published from the date of acceptance and that Panickar et al’s paper3 was published in the interim. However as noted in my reply4 the concept of differentiating between viral induced wheeze and multi-trigger asthma in preschool aged children is not widely known amongst my professional colleagues in emergency medicine or general practice. The paper by Martinez2 was published in 1995 yet it would seem that 14 years later this information is not widely known by clinicians who deal with this condition on a daily basis. This highlights the difficulties of knowledge translation as discussed in Chapters 3 and 4. In this case awareness of the issue prevents application of evidence into practice.
Lewis^5 dismisses the evidence, and promotes an anecdote based approach to practice. Sir Richard Doll highlighted the problems with using one’s own clinical practice as evidence for treatment effects as it lacks controls for confounders and bias^6. In many ways Lewis provides the prime example of why knowledge translation is so important. Lewis advocates the use of antibiotics for acute asthma when fever and cough is present and even advocates prophylactic use in adults. There is certainly no evidence to support the use of antibiotics in this way as a routine practice. Similarly Lewis uses peak flow meters as a marker of severity when spirometry is the better option and recommends tapering short courses of corticosteroids when there is no need to do this. If Theilhaber’s response highlighted the “awareness” problem then Lewis highlights the “belief” problem. Lewis clearly doesn’t believe the weight of evidence supporting many current asthma management recommendations. As noted in Chapter 4 there are patterns of resistance to evidence-based medicine and perhaps Lewis fits into the constitutionally conservative pattern. Chapter 4 also notes reasons why clinicians use treatments that do not work (such as antibiotics in asthma) and reasons such as their own clinical experience, natural history of the illness and the need to do something may explain some of the clinical practices mentioned by Lewis.

Bawale^7 raises issues of “application” of evidence as discussed in Chapter 3, though in contrast to the above example I will provide reasons why clinicians may choose not to apply the evidence Bawale cites. Bawale warns of the dangers of short courses of corticosteroids and cites a case series of three patients who developed avascular necrosis^8. Bawale is so concerned that he recommends counselling and consent for short courses of corticosteroids. Side effects of treatments are always an important consideration but how applicable is the evidence cited by Bawale? All three patients received dexamethasone. All three patients developed avascular necrosis of long bones between 12 months and two and a half years after therapy with dexamethasone, hence there is an association, but not a definite cause and effect. Indeed one patient with neurological deficits from a C4-5 disc protrusion who developed avascular necrosis of both humeral heads, was a painter and decorator and perhaps these factors were a contributor to his problem. In any event the doses of dexamethasone used were far in excess of prednisone equivalent doses recommended for asthma with one patient receiving up to 422mg of dexamethasone and two patients receiving dexamethasone for 32 days. Even if we accept that short courses of corticosteroids can, rarely, cause avascular necrosis, the cases provided by Bawale involve a different corticosteroid, at much
higher doses and for much longer durations of therapy. In this case being aware of the evidence and believing the evidence I would still not follow Bawale’s recommendation as on the whole I do not believe it would be applicable to the target patient population. This constitutes “judiciousness” in the use of evidence-based medicine. In certain individual patients with co-morbidities or risk factors for avascular necrosis, then this risk may make it an important consideration in the decision to apply the evidence. This reinforces the three components of evidence-based medicine, evidence, judiciousness and application to an individual patient.

These rapid responses are included here as they do illustrate a number of the concepts and challenges surrounding knowledge translation that have been mentioned in the previous chapters.

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7 Bawale R, Martin W, Imam S.. Rapid response to an article 'prescribe systemic steroids in acute asthma' BMJ rapid response 23 April 2009 www.bmj.com/cgi/eletters/338/apr03_1/b1234
Use of Ipratropium Bromide for Acute Asthma

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Suggested citation:
**Why is this important?**

Asthma is a common condition that continues to increase in Australia and globally. The prevalence of asthma in Australia is among the highest in the world, with over two million people affected. Asthma makes up a large proportion of presentations to emergency departments and patients often re-present with further deterioration over the next 12 months. The initial assessment of the severity of an asthma episode is critical in acute management. A recent multi-centre Australian study has shown that the vast majority of acute asthma presentations to Australian emergency departments are mild to moderate (95.5 per cent in children and 90.5 per cent in adults). In the management of severe acute asthma, which makes up just six per cent of cases, the addition of ipratropium bromide to the standard drugs used improves health outcomes with no significant additional side effects. However, there is little evidence to support use of ipratropium bromide in cases of moderate severity and it is not recommended in the management of mild acute asthma.

**Best available evidence**

Numerous clinical practice guidelines recommend that, along with oxygen, bronchodilators and beta-agonists, multiple doses of ipratropium bromide be used in the management of patients with severe and life-threatening asthma attacks, or those with a poor initial response to beta-agonist therapy. Australian guidelines indicate that ipratropium bromide can be used in the management of moderate acute asthma and recommend against its use in patients with mild acute asthma. These recommendations are based on the findings of two published systematic literature reviews. A Cochrane systematic review of acute asthma in children found that a single dose of ipratropium bromide was of no additional benefit in children with mild to moderate asthma. Another evidence-based review found that there was no apparent benefit of adding single doses of ipratropium bromide to treatment of those with mild to moderate asthma.

**Current practice**

The Snapshot of acute asthma study was a prospective, observational study involving 38 emergency departments in Australia. In children, nearly 50 per cent of patients presenting with mild asthma and 69 per cent of those presenting with moderate asthma received ipratropium bromide. In adults, the figures were 60 per cent and 83 per cent respectively.

**Implications**

There is substantial evidence that ipratropium bromide is of limited usefulness in acute episodes of mild to moderate asthma. Given that most presentations to the emergency department are mild to moderate in severity, many patients may therefore receive an expensive therapy with little evidence for its efficacy. In practice, the formal assessment of asthma severity is not part of routine procedure, which may lead to the over-treatment of many patients with less severe attacks. Whilst it is easy to focus on increasing the use of effective treatments, it is equally important that we do not continue to use treatments when there is no evidence to support their application. Using ipratropium bromide in accordance with best available evidence would provide cost savings without detrimental effects to patients and minimise the (albeit) small effect of medication reactions.

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**Severity of asthma in presentations to emergency departments 2000-2001**

- Mild
- Moderate
- Severe

**Use of Ipratropium Bromide for Acute Asthma**

Practice

Prescribe systemic corticosteroids in acute asthma

Steven Doherty, associate professor, director, emergency consultant

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Systemic corticosteroids reduce admission rates, relapse rates, and symptom duration and should be used for most acute exacerbations of acute asthma

The clinical problem

Globally, 300 million people are estimated to have asthma and the prevalence in most countries is increasing. Systematic reviews have found that systemic corticosteroids in acute asthma reduce admission rates, symptom duration, β-agonist use, and repeat presentations for medical care. However, evidence exists that corticosteroids are underprescribed in acute asthma, with prescribing rates ranging from <60% for mild asthma to <85% for moderate and severe asthma across multiple sites. Systemic corticosteroids are recommended and should be prescribed, unless there are other contraindications, for all but the mildest of acute exacerbations of asthma.

The evidence for change

Meta-analyses have reviewed the role of corticosteroids in acute asthma. A meta-analysis of seven randomised controlled trials (426 children aged 1-18 years) found that those who received systemic corticosteroids were discharged earlier (number needed to treat (NNT) 3) and were less likely to relapse within one to three months (odds ratio 0.19; 95% confidence interval 0.07 to 0.55, NNT=3). A meta-analysis of six randomised controlled trials (374 discharged adults and children) showed those receiving corticosteroids were less likely to relapse to the stage that they required additional care in the first week (0.36; 0.2 to 0.74); this effect was maintained for 21 days (NNT=13). The rate of subsequent hospital admissions in those patients was also lower (relative frequency 0.55; confidence interval 0.13 to 0.95) and the patients used β2 agonists less often.

A meta-analysis of 12 randomised controlled or quasi-randomised controlled trials (883 adults and children) found that using systemic corticosteroids within one hour of arrival at hospital decreased admission rates (odds ratio 0.40; 0.21-0.78, NNT=8). A meta-analysis of seven randomised controlled trials (1204 discharged adults and children) comparing rates of relapse at 7-10 or 16-21 days for high dose inhaled corticosteroids versus oral corticosteroids, found no significant difference in rates of relapse, but the heterogeneity of studies meant there was insufficient evidence to recommend inhaled corticosteroids as an alternative treatment.

Despite evidence of effectiveness, studies have shown that systemic corticosteroids are underprescribed. The 'snapshot of acute asthma' study was conducted in 38 Australian emergency departments and comprised 1340 acute presentations of asthma. It found prescribing rates of 59%, 36%, and 62% in mild, moderate, and severe exacerbations respectively.

Barriers to change
Barriers to change may occur at the level of the patient but also at the level of the individual clinician, the healthcare team, the organisation (hospital), and the broader, national healthcare system. Patient care that is based on evidence-based guidelines for asthma has been shown to improve asthma outcomes, and guidelines, if effectively implemented, can serve to ensure that both patients and clinicians are appropriately educated about the role of corticosteroids. Yet implementation of guidelines remains an international challenge, and in emergency departments at least, barriers to change include a lack of time and resources; confidence among clinicians in what they are already doing; a chaotic, uncontrolled environment; and guidelines being available in formats that are difficult to use and access.

One potential solution is for organisations to use an evidence-based implementation strategy to effect change. Two studies of such a strategy for asthma guidelines found an increase in the use of systemic steroids in acute asthma. A pre-intervention and post-intervention audit study in children presenting to emergency departments found that the use of systemic corticosteroids rose from 74% to 82%, and in a controlled trial in adults presenting to emergency departments the use rose from 65% to 84%. Key implementation strategies used in these studies included the use of senior medical and nursing staff as opinion leaders; reminders; audit and feedback to staff; education; and the reformatting of asthma guidelines for use in the clinical record. In these trials, of the 69 adults and children with moderate to severe presentations, 97% were prescribed systemic corticosteroids (unpublished data).

How should we change our practice?

Patients presenting with acute asthma should receive corticosteroid doses in the order of 1 mg/kg a day of prednisolone (or equivalent dose of another corticosteroid). This dose is based on a double-blind randomised controlled trial comparing three dosing regimens in 66 patients. Systemic steroids should be prescribed for up to seven days in adults and for three to five days in children, with no need for tapering the dose.

Although inhaled corticosteroids may yet be proved to be as effective as oral corticosteroids, most evidence to date favours systemic corticosteroids both in the acute stage and after discharge.

Methods
I searched the Cochrane database of systematic reviews using the search terms “acute asthma” and “corticosteroids” in the “keywords, titles and abstracts” field. From these results, I identified relevant systematic reviews relating to use of systemic corticosteroids in acute asthma.

Key points
- Prescribe systemic corticosteroids for all but the mildest exacerbations of acute asthma
- Systemic corticosteroids reduce admission rates, relapse rates, symptom duration, and requirement for “relever” medications, such as short acting B2 agonists
- An appropriate daily dose is 1 mg/kg a day of prednisolone (or equivalent dose of another corticosteroid) for up to seven days in adults and for three to five days in children
- Insufficient evidence exists that inhaled corticosteroids are as effective as oral steroids after acute asthma attacks
- Inhaled corticosteroids have not yet been shown to be as effective as oral steroids for acute asthma attacks
Cite this as: BMJ 2009;338:b1234

Change Page aims to alert clinicians to the immediate need for a change in clinical practice to make it consistent with current evidence. The change must be implementable and must offer therapeutic or diagnostic advantages for a reasonably common clinical problem. Compelling and robust evidence must underpin the proposal for change. We welcome any suggestions for future articles (changepage@bmj.com).

Contributors: SD is the sole contributor to this article.

Competing interests: None declared.

Provenance and peer review: Not commissioned; externally peer reviewed.

References


(Accepted 9 October 2006)
Delay in publishing leaves us all behind

As a final note, "Delay in publishing leaves us all behind" is often used to draw attention to the importance of timely publication of research findings. This phrase emphasizes the need for prompt communication of research results, as delays can impact the progress of science and the dissemination of knowledge. It serves as a reminder to researchers, institutions, and policymakers to prioritize timely publication to ensure that valuable insights are shared promptly with the scientific community and the public.
Rapid response to an article ‘prescribe systemic steroids in acute asthma’
21 April 2009

Dear Editor,

We read the ‘Commentary’ article by 2 Dobson with interest 1. The article mentions that the majority of acute exacerbations in asthma are not severe enough to warrant hospital admission, an assertion that we very much support. However, you may also argue that systemic corticosteroids should be used in a more widespread manner in the acidic exacerbations than is currently seen in clinical practice. This is what has been recommended to us by the National Institute for Health and Clinical Excellence (NICE) in their most recent guidelines on the treatment of asthma. We believe that this is an important point of discussion and debate.

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Consultant anaesthetist, Rose donated.

How we use evidence
21 April 2009

The ballet dancer, Leonid Ulanov (1874-1910), provides a stronger argument for how we use evidence.

Leonid Ulanov, a renowned ballet dancer and choreographer, was a master of his craft and a symbol of excellence in his art. His work in ballet, particularly his use of form and structure, has had a lasting impact on the dance world. The principles of his approach can be applied to the study of evidence-based medicine, where the development of evidence-based practices involves the evaluation and integration of available evidence to inform clinical decision-making.

In reference to the ballet, Ulanov emphasized the importance of form and structure in creating a coherent and effective performance. Similarly, in evidence-based medicine, the integration of evidence from various sources (including clinical trials, meta-analyses, and expert opinions) is necessary to provide a comprehensive and systematic approach to clinical decision-making.

Leonid Ulanov's ballet performances demonstrate the importance of form and structure in creating a coherent and effective performance. In the field of evidence-based medicine, the integration of evidence from various sources is necessary to provide a comprehensive and systematic approach to clinical decision-making.

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Consultant anaesthetist, Rose donated.
Jarring prevalence for adults is nearly too high?

Read by: Dr. John Doe

69th Annual Meeting

December 2020

The authors recommend an adjusted dose of jarring for adults due to higher prevalence. The recommended dose is based on the current evidence and the Food and Drug Administration’s (FDA) recommendations. By contrast, the FDA suggests a lower dose for adults, which is not nearly as high as originally thought.

While some practitioners believe otherwise, the authors cite several studies and clinical trials that support their findings. These studies show that adjusting the dose for adults can significantly reduce side effects and improve safety. The authors encourage practitioners to adjust the dose accordingly.

In most cases, adjusting the dose required no changes to the standard protocol. The authors suggest that practitioners should carefully consider the individual needs of each patient when adjusting the dose.

References


Sweat induced AAN

Posters: Sugar, Diabetes, and Sweat

Presented by: Dr. Jane Smith

December 2020

Sweat induced AAN refers to a condition where excessive amounts of sweat are produced due to various factors. This condition can have significant implications on the quality of life of individuals and can be managed with proper treatment and lifestyle changes.

The authors have found that managing factors such as diet, exercise, and medication can reduce the symptoms of sweat induced AAN. They encourage practitioners to work closely with their patients to develop a personalized treatment plan.

References


Emerging trends: Natural Perspiration

Posters: Aging, Health, and Perspiration

Presented by: Dr. John Doe

December 2020

Emerging trends in natural perspiration include the use of natural products, such as essential oils and herbs, to reduce excessive sweating. This trend is particularly popular among younger adults and those with sensitive skin.

The authors discuss the potential benefits of natural perspiration, including improved skin health and reduced dependence on prescription medications. They encourage practitioners to consider the use of natural products as part of their treatment plans.

References


Emerging treatment: Natural Perspiration

Posters: Aging, Health, and Perspiration

Presented by: Dr. Jane Smith

December 2020

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References


Evidence of Model

<table>
<thead>
<tr>
<th>Page 69</th>
<th>Page 70</th>
</tr>
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<tbody>
<tr>
<td>Evidence of Model</td>
<td>Page 70</td>
</tr>
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Chapter 6: Evidence-Based Implementation

This article published in the International Journal of Healthcare Quality Assurance presents the methodology of the implementation strategy used in the quantitative studies and introduces the concept of evidence-based implementation. The concept of an evidence based implementation for asthma has been built upon the evidence for the management of acute asthma (Chapter 2), the evidence for implementing change (Chapter 3) and an understanding of the principles of EBM (Chapters 4 and 5).

Evidence-based medicine has been defined as having three key components, with these being the **judicious** use of **best available evidence** applied **individual patients**. Using the definition of EBM as a template, then evidence-based implementation can be defined as, “the judicious use of best available evidence (for implementation) applied to individual departments (or health services).” This analogous definition retains the three core features of the definition of EBM.

Firstly an EBI requires the use of the best available evidence regarding implementation strategies. Whilst there are many unanswered questions regarding the best way to change behaviour or implement change, there is nonetheless a significant body of literature and evidence on the subject as discussed in Chapter 3.

Secondly, in the same way that individuals are different EDs are also different to one another. Whilst there are similarities in their role delineation, EDs have different staff members, different staff mixes, service different populations, have different policies and procedures and different processes of care. They are complex systems with different dynamics and in the same way that patients are individuals in the concept of EBM, so too EDs are individually unique in the concept of EBI.

Finally, EBM requires judicious use by the practitioner and judiciousness requires a knowledge and understanding not only of the evidence but of the individual patient. Similarly in EBI judiciousness is required and this means that the individual or team that is driving the implementation needs a thorough understanding not only of the evidence for implementation but also of the department.
Evidence-based implementation of evidence-based guidelines

Steven Doherty
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Abstract

Purpose: There is evidence that some strategies for guideline implementation are more successful than others. This paper aims to describe the process of developing an evidence-based guideline implementation strategy for a rural emergency department.

Design/methodology/approach: Participation in a nationally funded, research fellowship program involving attendance at workshops run by internationally renowned experts in the field of knowledge translation. Attendees at these workshops, associated reading and a literature review allowed these implementation strategies with the most supportive evidence of effectiveness to be determined.

Findings: A multi-faceted implementation strategy was developed. This strategy involved the use of an implementation team, as well as addressing issues surrounding individual clinicians, the emergency department team, the physical structure and layout of the ED and the culture of the department as a whole. Features audit and feedback, education, the use of prompts (clips) and evidence-based formatting of guidelines were all integral to the process.

Practical implications: It is postulated that an evidence-based implementation strategy will lead to greater changes in facility behaviour than other strategies used in quality improvement projects.

Originality/value: This is an important article as it describes the current and development of evidence-based interventions, which, if tailored to the individual hospital (as evidence-based medicine is tailored to the individual patient), has the potential to improve compliance with clinical guidelines beyond that achieved with more QI projects.

Keywords Medical practice, Knowledge transfer, Auditing, Australia

Paper type Research paper

Introduction

The transfer of knowledge to clinical practice, or knowledge translation, has been cited as one of the two main barriers preventing benefit from the biomedical sciences (Sung et al., 2005). Translating evidence into practice is difficult (God and Grimshaw, 2003) and some estimate that up to 50 percent of patients do not receive care compatible with the best available scientific evidence and that 20 percent of care is not needed or harmful (God and Grimshaw, 2009). These estimates themselves though have a poor evidence base (Davison, 2003).

Knowledge translation is possible when a well-designed strategy is used, with average changes of about 10 percent in studies of guideline compliance (God and Grimshaw, 2003; Grimshaw and Eccles, 2001). There is more research on strategies directed at health professionals (e.g. education, reminders, audit and feedback) than for strategies aimed at the patient, the medical department or health organization (God

Steven Doherty has a funded research fellowship with the National Institute of Clinical Studies.

The current research full text version of this article is available at www.emeraldinsight.com/0882-6004.htm

72
and Grimeshaw, 2003). There is evidence that passive implementation strategies are of limited value (Bero et al., 1998). Even though the knowledge translation evidence base is incomplete, there is sufficient evidence to guide implementation strategies, leading some investigators to raise the concept of an evidence-based implementation EBI (Grimeshaw and Eccles, 2004). Many attempts at implementing clinical behaviour change are based on the beliefs of the investigator (Grol, 1997) with no rationale provided for the choice of implementation method (Grimeshaw and Eccles, 2004). By developing an EBI strategy it is postulated that more significant improvements can be achieved.

This EBI was originally developed to implement guidelines for adult asthma in a variety of rural emergency departments (ED), as part of research fellowship with the National Institute of Clinical Studies (NICS). The NICS is an Australian government funded organisation seeking to increase the uptake of evidence into practice. In 2004, the Clinical Excellence Commission (CEC) commenced a pilot program to implement 12 pediatric guidelines into NSW emergency departments. The EBI strategy was suitable for adaptation for eight of these guidelines, asthma, gastroenteritis, bronchitis, croup, the febrile child, sore throat, sore ear and head injury.

**Aims**

This paper will describe the implementation strategy that was developed. This strategy was designed by reviewing evidence for effectiveness of various implementation strategies and applying them to the local context. The implementation strategy has since been used in a number of controlled trials and quality improvement (QI) projects. Data from these projects will not be presented in this paper, rather a detailed account of the implementation strategy and the rationale for that strategy will be presented.

**Methods**

In 2004, NICS ran a number of public lectures and workshops, conducted by internationally renowned experts in implementation and quality improvement. Speakers included Dr Richard Grol, Professor John Overtvitt, Professor Jonathan Lomas and Professor Dave Davis. From attendance at these workshops, the provided pre-reading material and a literature review an evidence-based approach to implementation was derived and the most appropriate interventions for the local setting were determined.

**Results**

An EBI and an evidence-based guideline (EBG) were developed. The intervention was multifaceted and involved an implementation team, identification of evidence-practice gaps, identification of barriers to change, development of an EBG - formatted in an evidence-based way, reminder systems, audit and feedback, face-to-face education and use of opinion leaders.

The implementation team consisted of the nursing unit manager, the director of emergency medicine, a senior emergency physician an ED clinical nurse specialist and a pediatric clinical nurse consultant. The team met approximately every four weeks for about an hour. The project team discussed issues with implementation from the "big picture", e.g. when to introduce a new guideline to small details such as photocopying and where to physically locate the guidelines in the department. The
A pilot audit was performed to determine which aspects of management of asthma could be improved and clinical indicators (CI) were derived. The implementation aimed to improve compliance with the following CIs:

- formal documentation of severity as mild, moderate or severe;
- use of spirometry in the assessment of severity;
- increasing the use of a short course of oral steroids;
- decreasing the use of ipratropium for mild asthma;
- increasing the use of spacer devices for administering medications;
- decreasing the use of antibiotics for allergic patients with acute asthma;
- increasing the use of short-term asthma management plans (stamps); and
- decreasing the use of chest X-rays.

**Barriers to change**

Barriers to change were considered at the levels of the patient, individual doctor or nurse, the emergency department team and organization of the department.

**The patient**

Barriers at this level were attributed to the false belief that nebulizers were superior to spacers as a method of medication delivery, and a lack of knowledge about reliever medications and the role of corticosteroids. Education was regarded as the best means to address these issues and patient information sheets were provided at the time of consultation.

**The individual doctor and nurse**

It was considered that some clinicians might not want to use guidelines for reasons that are outlined in the discussion. Before implementation, senior doctors and nurses were made aware of the planned changes and the rationale and evidence for the recommendations was discussed. Senior doctors were involved at routine departmental meetings and support of the senior nursing staff occurred after initial meetings, between them and the author, arranged on a convenience basis. Senior staff were encouraged to promote the use of the guidelines amongst junior staff.

Other clinician barriers were lack of knowledge about the NAC guidelines, the use and interpretation of spirometry and lack of access to pre-formatted STAMPS. All staff were made aware of the guideline and given a copy of it. Clinical nurse educators (CNE) in respiratory medicine conducted further education sessions on the use of the spirometer, and senior ED nurses took opportunities to teach more junior nurses about...
its use on an informal basis. The author in conjunction with the implementation team and the CNs developed a pre-formatted STAMP to be clipped to the guideline (along with the educational material mentioned above).

Implementation of guidelines

The emergency department team
A busy ED was the main barrier. A guideline pack, consisting of the EBG, patient educational material and STAMPs were attached to the patient record at triage and if able spirometry was performed as part of the triage assessment. This was difficult when triage was busy so it became necessary for the nurse in the ED caring for the patient to perform the spirometry. The nurse or doctor caring for the patient could commence them on the guideline if they had not been commenced at triage.

Another challenge was to inform and educate locum staff about the guidelines. Locum staff form a large part of the medical workforce in many rural hospitals, and are transient, often working for periods of a week to a month.

Organisation of the department
Barriers at this level included the lack of a regular nursing staff educational meeting where issues such as guidelines could be discussed, lack of staff to make notes and lack of a staff member with a dedicated QI role. In the absence of regular nurse educational meetings, occasions such as handover rounds and informal meeting were utilised to facilitate the implementation. The author was able to take on the role of auditing.

It was hoped that the electronic database, the emergency department information system, could be programmed to provide pop up reminders to use the guideline based on entering presenting symptom data. However, this was unable to be achieved and was another barrier to implementation.

Other barriers arose at the grass roots level during the course of the study. For instance, a few weeks into the study the STAMP was inadvertently photocopied onto the reverse side of the guideline, instead of being on a separate sheet of paper. The guideline became part of the medical record and hence to give the patient the STAMP staff had to photocopy it. This subtle change was associated with a marked reduction in STAMPs being handed to patients.

With multiple guidelines being developed and implemented it became necessary to acquire a cabinet to file the various guidelines in and for clerical staff to develop a system to maintain adequate numbers of guidelines, patient education handouts and STAMPs.

An evidence-based guideline
The NAC handbook (National Asthma Council, 2002) contains an evidence-based approach to the assessment and management of asthma in the ED for both adults and children and forms the basis of NSW Health's guidelines for the ED management of asthma. One of the keys to our implementation was to format these recommendations into a single, one-sided A4 page that could be incorporated into the medical record. Our guideline (see Appendix) incorporated the main features of the NAC handbook recommendations and included some additional assessment features on work of breathing and additional management recommendations for the use of spacers and non-use of antibiotics, especially for afebrile patients.
The guideline is simple to use, simply formatted, utilizes tick boxes to decrease workload, is designed to be signed by both medical and nursing staff, is based on reputable sources, is not time consuming and simplifies decision making.

This guideline format developed for adult asthma has subsequently been adapted for other conditions and has also been adapted and adapted for use in other hospitals.

Reminders
The guideline itself was designed to be a reminder by being part of the medical record, and signed by medical and nursing staff. The guideline was commenced at triage and the initial assessment section was compatible with standard triage practice and incorporated a section on spirometry, which was one behaviour that we were seeking to target.

Senior doctors were encouraged to remind junior staff to use the guideline and senior nurses were encouraged to promote and remind both nurses and doctors of the guideline.

Notices were placed on the walls in the department, the telesroom and bathroom facilities reminding staff of the guidelines and giving notice of when the next guideline would be introduced.

Audit and feedback
Audit and feedback was used during the follow-up data collection phase, with graph and or table information displayed on notice boards in the department at about monthly intervals. The author performed all audits. Aggregate data only was provided and no individual clinician compliance rates were included. This method also served as a reminder to clinicians of the guidelines.

Auditing concentrated on those clinical indicators identified in the evidence practice gap.

Education
Education related to the project and the guideline. Prior to introducing the first guideline the author spoke to nursing staff at the afternoon shift handover, for five consecutive weekdays, advising them of the guideline and the aim of the guideline.

These sessions took about 10-15 minutes. Not every nurse who worked in the department was briefed at these meetings but many were. The author opportunistically discussed the guideline with nurses who had not been present at any of the aforementioned meetings.

Medical staff were educated regarding the evidence base for the guideline at one of the departaments routine weekly education sessions. Similarly, they were educated regarding the use of the guideline.

Discussion
The evidence practice gap for asthma that our implementation was designed to address identified eight areas. Three of these were reviewed in the snapshot of asthma study (Kelly et al., 2003), a national study involving 38 Australian EDs, and as with our audit the same problems were found. There was over use of intravenous, under use of oral steroids and under use of spacers. The evidence – practice gaps identified for a number of clinical conditions in the CEC pilot study – are also similar across a range of
different hospitals. Hence, it is likely that some of the gaps evident in our own hospitals are probably occurring in other departments too, to greater or lesser degrees.

Most studies of guideline implementation have focused on changing the behaviour of the individual, often with a single intervention, and have not focused on the practice environment (Solberg et al., 2000a; Solberg, 2001b; Dawson et al., 1999). There is evidence though that focusing on individual clinicians will not be successful and that multilevel strategies are required (Solberg et al., 2000a; Solberg, 2001b; Dawson et al., 1999; Grol, 2003). Experienced guideline implementers have identified the capacity of the organisation to change, the infrastructure for implementation, implementation strategies, medical group characteristics and characteristics of the guideline as important factors in achieving change (Solberg et al., 2000a). This group viewed implementation as being a complex process and favoured using multiple strategies. It was clear that organisational factors needed to be addressed (Solberg et al., 2000a; Dawson et al., 1999; Doussan et al., 2001). Part of our challenge was to address the cultural mind set. For instance, if a patient presents with chest pain they are taken to a monitored bed, put on oxygen, given an aspirin and have a 12 lead ECG performed. It is so ingrained it occurs automatically. Our challenge is to ensure that this approach is applied to a much broader range of conditions. For example, antibiotics should be given oxygen, have spirometry performed and receive appropriate medications.

Given that most interventions can be successful in some circumstances but none are effective in all, Grilli and Lomas, 1994 another challenge was to consult the literature on implementation and gain an understanding of what interventions were most likely to be successful in our environment.

A key component of our implementation was the development of usable guidelines. Guidelines can be considered as systematic statements to help clinicians and patients make decisions about care (Solberg et al., 2000a). A review (Grol and Grimshaw, 2003) of four studies and found that compliance with guidelines was better with:

- type of health problem (compliance better for acute conditions);
- better quality evidence;
- compatibility of recommendation with existing values;
- less complexity of decision making;
- fewer new skills needed
- less organizational change;
- more concrete description of desired performance.

Complexity of the guideline decreases compliance whilst trialability increases it (Grilli and Lomas, 1994). Guidelines are more likely to be used if the recommendations are clear, not controversial, do not require a change in practice (Grol et al., 1998) and are evidence-based (Doussan et al., 2001; Grol et al., 1998). For adult asthma, guidelines and statements from learned bodies and local guidelines were seen as important influences on practice (Dawson et al., 1999). Insofar as possible the guidelines were developed with these features in mind.

Grol and Wensing (2004) cite data from a Dutch study (Dijkstra et al., 2000) on factors influencing physician guideline compliance for the management of diabetes. Features that lead to guidelines not being used were targeted with our intervention. In the Dutch study 45 percent of physicians felt the guideline would not be read — by
making our guideline part of the medical record we were attempting to make sure the guideline was read. The "Avis solution" is a means of getting the guideline off the shelf and into a usable format in the patient’s clinical record. In the Dutch study 34 percent felt the guideline was too time consuming, so our guideline was developed to fit on a single page, with tick boxes and there was no duplication of workload. The implementation team has taken the view that guidelines are tools, and that tools will be used if they make the job easier. The guidelines have been concisely presented in a usable format and endorsed by the senior staff. The formatting of our guidelines is suited to "standing orders" and nurse initiated management of asthma has been common practice in the department. There is evidence that systems changes such as standing orders can have positive impacts on behavioural change (Solberg, 2000b).

Guidelines are not self-implementing (Solberg et al., 2000a) and Grinshaw and Eccles (2004) have reported results of a systematic review of 235 rigorous evaluations of different guideline dissemination and implementation strategies published up to 1998. Of studies, 85 percent of studies showed improvement in compliance with guidelines. There was a 10 percent improvement with guidelines across studies. Most dissemination and implementation strategies resulted in small to moderate improvements in care, 14.1 percent in 14 cluster RCTs of reminders, 8.1 percent in four RCTs of dissemination of educational material, 7 percent in five RCTs of audit and feedback and 6 percent in 13 C-RCTs of multifaceted interventions. There is also other evidence that reminders (Grul and Grinshaw, 2003; Grinshaw et al., 2001) audit and feedback (Green, 2001; Jambroos et al., 2003) and outreach education (Thomson et al., 1997a) are the most effective strategies, even if the benefits are only modest.

However, there are few descriptions of how to implement a reminder nor any studies of it (Solberg et al., 2000a). Our method was to address the system at the point of triage with the reminder being a part of the clinical record. We did use other reminders, audit and feedback on the notice board, signs on walls, informal reminders from clinicians and formal reminders at educational sessions and it will require a qualitative study to determine which of our reminder techniques was the most useful. Similarly, there is little evidence about what form audit and feedback should take, who should perform it or how often.

There is more evidence for outreach education (Thomson et al., 1997a) than passive dissemination of educational material (Solberg, 2000b; Freemantle et al., 1996), the latter of which has shown no statistically significant improvements in practice (Freemantle et al., 1996) and is not thought sufficient to persuade people to change (Dopson et al., 2001).

The use of opinion leaders has some evidence to support it (Solberg, 2000b; Dopson et al., 2003; Thomson et al., 1997a) and was considered important for our center. Our ED has a large proportion of junior doctors with relatively few senior doctors to supervise them. The culture of the department is such that the senior doctors are frequently asked to review patients. Given the dependence of junior doctors on the senior staff, it intuitively made sense that the junior doctors would value the opinions of the senior doctors with regard to guideline implementation. There is also evidence from a study in adult asthma that advice from senior colleagues rate highly in changing behaviour (Dowse et al., 1998).

There has been criticism that there is little evidence to demonstrate that QI programs work (Overwijn and Casalino, 2003). Others recommend that the research agenda in QI needs to move away from whether or not something works and focus
instead on why it works (Walsh and Freeman, 2002). Controlled trials of our strategy have demonstrated its effectiveness and it is likely that the changes were due to our intervention and not other confounding variables. As a follow up to those trials qualitative studies will be conducted to determine what aspects of the implementation were the most effective. Issues such as volume of cases and introduction of multiple guidelines will be explored in these future studies.

One criticism of our approach may be that we are using the triage process as a diagnostic process. All the guidelines have an assessment component at the beginning consisting of appropriate triage observations. The initial assessment will detect significantly ill patients regardless of their ultimate diagnosis and medical staff are aware they can remove or apply patients to the guideline as they see appropriate.

Another criticism of our approach could be that we are seeking to achieve intermediate or surrogate outcomes. We are not seeking, for example, to demonstrate reduced admission rates but merely better compliance with guideline recommendations. Nonetheless, evidence supports our view that these surrogate outcomes reflect clear clinical benefits, e.g. a short course of corticosteroids will reduce admission rates, representations and symptom duration (Rowe et al., 2004a, b).

Summary
This article has attempted to provide the methods used and the rationale behind those methods for implementing a number of guidelines into a variety of rural hospitals. By basing our intervention on evidence from the QI literature we have attempted to derive an EBI. In addition, by testing this implementation in RCTs and then qualitatively analyzing the reasons for change, it is hoped the overall project will provide further evidence for the most effective strategies to implement clinical change.

References


### Adult Asthma - ED Guideline

**Initial Assessment** (Tick the feature)

**Symptoms**

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe/Life-Threatening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical exhaustion</td>
<td>No</td>
<td>Yes, may have paroxysmal chest wall movement</td>
<td></td>
</tr>
<tr>
<td>Tachycardia (adults)</td>
<td>&lt; 100bpm</td>
<td>100-120bpm</td>
<td>&gt; 120bpm</td>
</tr>
<tr>
<td>Work of breathing</td>
<td>Nil increase</td>
<td>Minimal to moderate increase</td>
<td>Working hard</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>&lt; 25</td>
<td>&gt; 25</td>
<td></td>
</tr>
<tr>
<td>Cough</td>
<td>No smoke present</td>
<td>May be present</td>
<td>Likely to be present</td>
</tr>
<tr>
<td>Wheeze intensity</td>
<td>Variable</td>
<td>Moderate local</td>
<td>Moderate local, rapid</td>
</tr>
<tr>
<td>Peak expiratory flow rate (PEF) (adults)</td>
<td>&lt; 75%</td>
<td>50-75%</td>
<td>50-75%</td>
</tr>
<tr>
<td>Systolic BP or ABP</td>
<td>&lt; 90%</td>
<td>90-105%</td>
<td>90-105%</td>
</tr>
<tr>
<td>Tracheal examination</td>
<td>Nil</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>Doctor assessment of severity</td>
<td>Nil</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
</tbody>
</table>

**Initial Management**

**Treatment**

<table>
<thead>
<tr>
<th></th>
<th>Mild Attack</th>
<th>Moderate Attack</th>
<th>Severe/Life-Threatening Attack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Nebuliser</td>
<td>Salbutamol</td>
<td>Salbutamol</td>
<td>Salbutamol</td>
</tr>
<tr>
<td>Armstrong</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
</tr>
<tr>
<td>Medication</td>
<td>As per Doctor's advice</td>
<td>As per Doctor's advice</td>
<td>As per Doctor's advice</td>
</tr>
<tr>
<td>Arterial blood gases</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
</tr>
<tr>
<td>Caffeine</td>
<td>Nil or Nil</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
</tr>
<tr>
<td>Other (e.g., dual chamber)</td>
<td>Nil or Nil</td>
<td>Nil or nil</td>
<td>Nil or nil</td>
</tr>
</tbody>
</table>

**Infliximab given**

- Yes [□]
- No [□]

---

**Figure A1.**

---

**About the Author**

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Chapter 7: Trials of Evidence-Based Implementation of Asthma Guidelines

This chapter presents three quantitative papers on the implementations of asthma guidelines in the ED. The guidelines are concerned with the assessment and management of acute asthma in the ED.

These papers build on the clinical indicators developed in Chapter 6 and utilise the implementation methodology outlined in Chapter 6.

The papers are different in either hospital type, methodology or patient population.

One paper is set in smaller rural hospitals with five hospitals acting as control and five acting as study hospitals. All 10 hospitals were staffed by GP VMOs and had nursing staff who were not dedicated to the ED but tended to patients in the ED amidst their other roles.

Another paper describes a controlled trial in larger rural hospitals with dedicated ED staff. One hospital acted as a control and the other acted as the study hospital.

The third paper is a before and after paper of paediatric asthma management.
Evidence-based implementation of adult asthma guidelines in the emergency department: A controlled trial

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Hunter New England Health, 1University Department of Rural Health, University of Newcastle, Newcastle, and 3Emergency Department, Tamworth Rural Referral Hospital, Tamworth, New South Wales, Australia

Abstract

Objective: To determine if an evidence-based implementation (EBI) strategy could lead to the successful implementation of guidelines for the management of adult asthma in a large rural ED.

Methods: This was a pre- and post-intervention trial, comparing data for seven clinical indicators from a study hospital and a control hospital. Retrospective pre-intervention audits were conducted at the study hospital for 3 months (1 April–30 June 2004) and the control hospital for 4 months (1 March–30 June 2004). The effect of an EBI to implement established guidelines for the management of asthma at the study hospital was compared with the effect of a mail-out of guideline booklets and wall charts to the control hospital. Post-intervention audits were then performed at both hospitals. Sustainability of the EBI was gauged by 12 month follow-up data at the study hospital.

Results: There were 55 presentations of adult asthma at the study hospital in the pre-intervention phase and 67 post-intervention. The corresponding numbers for the control hospital were 51 and 42, respectively. Following the EBI there were significant improvements at the study hospital for the documentation of severity (27% vs 6%, P < 0.01), use of spironolactone (38% vs 84%, P < 0.01), medication delivery via nebulizer device (0% vs 28%, P < 0.01), use of systemic steroids (68% vs 84%, P < 0.05), use of written short-term asthma plans (14% vs 82%, P < 0.01), reduction of inhaled corticosteroid use in mild asthma (43% vs 16%, P < 0.05) and reduction in antibiotic use in allergic asthma (37% vs 6%, P < 0.01). For the control hospital there was a significant increase in spirometry use from 2% to 40% (P < 0.01) for seven clinical indicators combined, compliance with the guideline increased from 38% to 79.1% (P < 0.01) at the study hospital, whereas there was no change at the control hospital, 44.3% to 45% (P = 0.73) There were 56 presentations at 12 month follow-up at the study hospital and compliance with the seven clinical indicators was 78.2%.

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Conclusion: An EBI significantly improved compliance at the study hospital with no improvement noted in the control hospital. These improvements were maintained at 12 month follow up. An EBI can lead to significant improvements in the management of asthma at a large rural referral hospital ED and might have implications for hospitals with similar roles and profiles.

Keywords: asthma, evidence-based implementation, knowledge translation.

Introduction

The prevalence of asthma among Australian adults is one of the highest in the world with 10–12% of people affected. Evidence-based guidelines form the basis of New South Wales (NSW) Health’s guidelines for the management of acute asthma. Despite this evidence these guidelines are not always followed. Developing guidelines is an important component in summarising evidence from research, but unless there is a successful implementation process, the translation of this knowledge into clinical practice will not necessarily occur. Translating evidence into clinical practice is difficult and remains a major barrier to improving health care. Ineffective implementation strategies can impair the use of guidelines in clinical practice.

Studies demonstrate a range of strategies for implementing guidelines with varying success and no definitive best strategy for all occasions. There is an evidence base for implementing change in clinical behaviour, although the evidence base is seldom used. Most implementation studies provide no rationale for the intervention chosen and offer no proof that any change in practice was due to the intervention. In addition, the intervention is generally not sufficiently detailed to allow others to reproduce the same methodology.

There is evidence that traditional strategies, such as mail-outs of guidelines and wall charts, are ineffective and some researchers question whether evidence-based implementation (EBI) of evidence-based guidelines is possible.

Evidence-based medicine is a triad of best available evidence and clinical judgement applied to an individual patient. This triad can be extrapolated to evidence-based implementation. That is, an EBI is a triad of best available evidence (for implementation of guidelines for example), judiciously used and applied to an individual department, unit or health service. In the same way that evidence-based medicine needs to take into consideration the unique characteristics of the individual patient, so too an EBI needs to take into account the unique characteristics of a department or hospital.

The aim of the present study was to determine if an evidence-based approach to implementation could successfully lead to the translation of evidence-based guidelines for the management of acute asthma into clinical practice in a rural referral hospital ED.

Methods

An EBI strategy was used to implement guidelines for the management of asthma. A pre- and post-intervention trial was conducted, comparing data from the intervention hospital with the control hospital. Tamworth Rural Referral Hospital was the intervention hospital and Armidale district hospital was the control hospital. At the intervention hospital, baseline data were collected from 1 April to 30 June 2004 and follow-up data from 1 September to 30 November 2004. At the control hospital, baseline data were collected from 1 March to 30 June 2004 and from 1 September to 31 December 2004. Twelve month follow-up data were collected for the intervention hospital from 1 August 2005 to 31 October 2005. Ethics approval was granted from the New England Area Health Service ethics committee.

Tamworth ED has an annual census of approximately 50 000 patients with an admission rate of 15%. It has specialist emergency physician cover 8 h per day with occasional 16 h per day cover. The remaining medical staffing is predominantly junior doctors (1–2 years postgraduate) and junior locum staff. Armidale ED has an annual census of approximately 15 000 patients with an admission rate of 15%. It has no specialist emergency physician cover or junior doctors and is staffed by career medical officers with extensive emergency medicine experience. Both departments have dedicated, emergency-trained nursing staff.

An EBI was devised and this has been extensively detailed previously. Key features of this implementation were:
Box 1. Evidence-practice gaps identified

Lack of formal documentation of severity (mild, moderate or severe) in the clinical record.
Low rates of spirometry for the assessment of acute attacks.
No use of metered dose inhalers with spacers/peppers for medication delivery.
Overuse of ipratropium for mild asthma.
Underutilization of systemic corticosteroids.
Low utilization of written short-term asthma management plans (STAMP).
Overuse of antibiotics for acute asthma in acerbate patients.

1. Identifying evidence practice gaps (see Box 1) that served as our clinical indicators for the study.
2. Identifying barriers to change at the level of the patient, individual doctor or nurse, the ED team and the organization and processes within the ED.
3. Reformulating the National Asthma Council (NAC) guidelines into a simple, usable format, consisting of a single-sided A4 tick-box guideline. This was a working document and incorporated into the medical record at Usage.
4. The use of reminders. Methods used included the guideline itself as a reminder in the notes, senior staff informally encouraging the use of the guidelines during clinical shifts, reminders during formal education sessions and notices placed within the department.
5. Audit and feedback was posted as aggregate data in the ED team at approximately monthly intervals.
6. Education sessions were arranged to coincide with routine department teaching and updates about the project were provided informally. Nursing staff were educated about the project during the afternoon handover each weekday in the week before the guidance was introduced.
7. An implementation team.
8. The use of local opinion leaders.

The control hospital was not subject to an EBI. The NAC asthma management handbook and NSW Health asthma guidelines had previously been distributed to the ED and NSW Health wall charts had previously been mounted in the department as laminated wall charts.

Baseline audits established the rates of compliance for the seven clinical indicators (Box 1) for the two EDs. All data were extracted using a preformatted data collection form by the lead author.

Formal assessment of severity was infrequently documented prior to intervention. At the time of the baseline audit a retrospective assessment of severity was made, based on the features described in the NAC handbook. Any one feature of "moderate severity" leads to classification as moderate, and any one feature of "severe" leads to classification as severe. The only caveat was if the only feature was pulse rate, the reviewer had to make a decision based on the median (emergency), amount of previous salbutamol use and any other factor that might have influenced pulse rate. A k=0.5 analysis was undertaken for this clinical indicator (CI) in the pre-intervention phase, by taking a random sample of 16 patient records and having them reviewed by another emergency physician. Kappa analysis was not undertaken for the other indicators.

For all data collection periods, the Emergency Department information system was searched to identify all patients (admitted and discharged) with an ICD9 diagnosis of asthma at the study hospital. Only patients with a final diagnosis of asthma aged between 16 years and 70 years inclusive were included. The control hospital had a different electronic database, "Mr ED. This database was searched to identify patients discharged from the ED with a diagnosis of asthma. The ICD9 discharge diagnoses for asthma were used to identify these patients admitted to the control hospital during the study periods.

All data were entered into a de-identified database. For an individual clinical indicator (e.g., the prescribing of corticosteroids) were excluded if the patient
was already on the treatment prior to proceeding to the ED.

The a priori \(x^2\) test sample calculation, resulting in a
total sample size of 100, was based on the following
parameters: effect size = 0.3, alpha = 0.05 and power =
0.85. Based on annual treatment adherence with asthma, it was
anticipated that 2 month data collection periods at the
study hospital and 4 month data collection periods at
the control hospital would achieve these numbers.

Data for all seven indicators in both the study and
control hospital were subject to \(x^2\)-testing (s2info
version 3.3). In cases where at least one expected cell value
was less than 5, Fisher exact tests (two-tailed) were
used. Aggregate data, representing the sum of compli-
cance for the seven clinical indicators, were also subject to
\(x^2\)-testing.

**Results**

For the study hospital there were 55 patients in the pre-
treatment phase and 87 in the post-treatment
phase. For the control hospital these numbers were 51
and 42, respectively. The sex ratios, mean age and
range and grading of severity are shown in Table 1.

The sex proportion and mean ages were similar prior
to and post-intervention at both hospitals. Given the low
number of patients with severe asthma statistical
analysis of assessment of severity compared mild
asthma with moderate–severe combined. In the study
hospital there was a significant change in the assess-
mnt of severity with more patients being assessed
as moderate–severe after the intervention (\(P = 0.03\),
\(\chi^2 = 4.5, 1\) degree of freedom). There was no significant
change in the control hospital (\(P = 0.5\), \(\chi^2 = 0.4, 1\)
degree of freedom).

Table 2 shows the pre- and post-intervention data for
both hospitals for the seven individual CI and their
aggregate. It also includes data for spirometry or peak
extpiratory flow rate (PEFR).

Figure 1 shows the aggregated compliance for the
seven clinical indicators in the study hospital at base-
line, post-intervention and at 12 month follow up. At
12 month follow up there were 68 patients, and 46

<table>
<thead>
<tr>
<th>Table 1.</th>
<th>Patient sex, age and asthma severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Study hospital</td>
</tr>
<tr>
<td></td>
<td>Pre-intervention</td>
</tr>
<tr>
<td></td>
<td>(n = 55)</td>
</tr>
<tr>
<td>% Male</td>
<td>255</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>33.3</td>
</tr>
<tr>
<td>Age range (years)</td>
<td>16–70</td>
</tr>
<tr>
<td>Asthma severity, n (%)</td>
<td>30 (55.5)</td>
</tr>
<tr>
<td>Moderate severity, n (%)</td>
<td>11 (20.0)</td>
</tr>
<tr>
<td>Severe severity, n (%)</td>
<td>8 (14.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2.</th>
<th>Clinical indicator data prior to and post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
<td>Study hospital</td>
</tr>
<tr>
<td></td>
<td>Prior to (%)</td>
</tr>
<tr>
<td>Documentation of severity</td>
<td>35/55 (65)</td>
</tr>
<tr>
<td>Spirometry</td>
<td>21/55 (38)</td>
</tr>
<tr>
<td>Spirometry or PEFR</td>
<td>21/55 (38)</td>
</tr>
<tr>
<td>Spacer use</td>
<td>9/40 (23)</td>
</tr>
<tr>
<td>Ipratropium and short-asthma</td>
<td>16/53 (46)</td>
</tr>
<tr>
<td>Serco-x-n.e.</td>
<td>9/40 (23)</td>
</tr>
<tr>
<td>STAMP</td>
<td>6/44 (14)</td>
</tr>
<tr>
<td>Antibiotics prescribed</td>
<td>19/52 (37)</td>
</tr>
<tr>
<td>Aggregate</td>
<td>17/76 (22)</td>
</tr>
</tbody>
</table>

PEFR = peak expiratory flow rate; STAMP = short-term asthma management plan.
 Figure 1. Aggregate compliance with the clinical indicators at 12-month follow up at the study hospital (ii) Baseline; (ii) post intervention; (i) 12 month follow up.

The individual clinical indicators were complied with on 319 occasions. The figure shows that the improvement in aggregate compliance was sustained 12 months after the intervention.

The independent reviewer concerned with the initial audit assessment in 14 of the 16 cases yielding a kappa result of 0.78, 95% CI 0.69-1.07.

Discussion

These results demonstrate that an EBI can change clinician behaviour and significantly increase compliance with guidelines. Attempts to increase compliance with guidelines can expect to yield changes in the order of 30%. Changes in compliance were of much greater magnitude in the present study. The intervention was focused on ED processes and organization than individual clinicians. There is evidence that targeting individual clinicians alone is of limited value in a complex environment such as a busy ED, and that the practice environment itself also needs to be addressed. In addition to the magnitude of the improvement, the intervention also resulted in the significant improvements for all seven clinical indicators being maintained at 12 months.

The A1 guideline adhered to principles that are known to increase compliance with guidelines, being compatibility with existing beliefs, simplicity, reducing or not increasing workload, being well validated, being from a respected source and requiring fewer new skills to be learned. In addition, a recent study has demonstrated that doctors prefer guidelines located on the front of the patient chart, which was our method.

Reminders, audit and feedback and education have been shown to be the most successful drivers of change and all these were used as part of the intervention, with reminders taking many forms. Senior clinical staff supported the change and acted as opinion leaders. The evidence for opinion leader use was considered relevant to the present study as the department has a large number of rotating junior medical staff with relatively few senior medical staff. In this context the leadership role of senior clinicians was felt to be of importance.

The intervention was associated with a significant change in the assessment of severity of asthma, with more patients being classified as moderate and less as mild or severe in the study hospital but not in the control hospital. This might have been due to a more standardized assessment or increased use of more objective measures such as spirometry. However, there are many confounders and this change in assessment of severity might also be due to other factors such as seasonal variation and change of staff.

There was a low rate of formal documentation of severity in the notes in the pre-intervention phase. Assessment of severity is important as evidence-based treatment for acute asthma varies depending on the severity. Kappa analysis confirmed that this method of retrospective review made an adequate assessment of severity. Nevertheless, the retrospective assessment of severity from the clinical record, even if based on sound criteria, remains a limitation of the present study.

Post intervention only one patient in the study hospital did not have the severity of the attack documented in the clinical record. Nearly every patient in the follow-up period had a completed copy of the guideline within the clinical record and it is likely that the success of getting the guideline incorporated into the clinical record at triage contributed to this.

Spirometry is preferred over peak expiratory flow for diagnosing asthma. There was a significant increase in spirometry at both hospitals, but at the control hospital the increase in spirometry was outweighed by an even greater decrease in peak expiratory flow, such that overall significantly fewer patients and some objective measure of lung function.

There is strong evidence to support the use of spacer devices, the restriction of intravenous to severe episodes only, and a short course of systemic corticosteroids following an acute attack in preference to inhaled...
There is also evidence that patients want written instructions and advice for the first 24 h after an acute asthma attack, and a readily available preformed short-term asthma management plan might have facilitated the increased compliance with this indicator. There is little role for antibiotic use in acute asthma and the intervention reduced antibiotic prescribing for sputum patients.

Given the high prevalence of asthma, one might expect that compliance with the seven clinical indicators combined might have been higher than the baseline 38%. However, the use of inhaled steroids for mild asthma in the present study was similar to that published 12 years previously in the nearest major tertiary hospital, despite guidelines being available at that time. Similarly the baseline rates for corticosteroid use and spacer use were similar to those in the national snapshot of asthma study. This highlights the challenge of knowledge translation and supports the assertion that getting evidence into practice is one of the major barriers preventing benefit from biomedical research.

There are a number of limitations to the present study. The limitation of retrospective assessment of severity has already been discussed.

During the course of the present study other projects were occurring across the area, including a pilot project of paediatric asthma guidelines run by the Clinical Excellence Commission, a collaborative for chronic obstructive pulmonary disease and an education campaign by clinical nurse specialists including spacer use and asthma management. These projects had the potential to impact on the ED management of adult asthma, and might explain, for instance, the low bronchodilator use seen at the control hospital.

The absence of a more evenly matched control hospital is another limitation. The control hospital was the next largest of 16 other hospitals within the area health service. Whereas it was a rural referral hospital, had 24 h on-site medical cover for the ED and nursing staff dedicated to the ED, it was overall a less busy department with less specialist input, though similar acuity and admission rate profile. The ED at the control hospital had a very different medical staffing profile with no specialist emergency physicians, no junior medical staff but a more stable workforce with no rotating terms and less reliance on junior staff. The intervention was focused on ED processes and organization than individual clinicians but the staffing profiles are quite different and the significance of these differences is unknown.

Knowledge translation is complex and no single strategy is suitable for all situations. The principle of an EBI is that the evidence for change is tailored to the uniquely individual department. Hence this intervention was designed specifically for this hospital ED. The intervention, with local variation, might be applicable to other rural and metropolitan ED with similar characteristics, although this cannot be stated from the present study alone. A similar trial in eight smaller, general practice-run, rural district hospitals, using similar methodology, demonstrated a significant improvement in guideline compliance although not to the same magnitude as seen in the present study.

The initial audit demonstrated that compliance with some clinical indicators was poor, and there is evidence that improvement is greater when the starting base is lower. These results cannot therefore be extrapolated to departments that are performing better in these areas.

All outcome measures were surrogate and a much larger study would be required to demonstrate a decrease in admission rates, adverse events, length of stay, representations or symptom duration associated with improved compliance with asthma guidelines. Nonetheless, evidence supports our view that these surrogate outcomes lead to clinical benefits, for example a short course of systemic corticosteroids will reduce admission rates, representations and symptom duration.

Conclusion

The present study demonstrates that an EBI can significantly improve compliance with guidelines with the potential to achieve much greater gains than in many previously published quality improvement projects. The intervention was successful in improving compliance with all seven clinical indicators and the gains were maintained at 12 month follow up. The study design has also demonstrated that the changes in clinical practice were more likely due to EBIs rather than some other confounding variables.

Acknowledgements

The authors would like to acknowledge the contribution of Associate Professor Christian Alexander for advice and assistance with the statistical analysis.
implementation of evidence-based guidelines

Author contributions

SRD was the principal author, drafted the manuscript, led the implementation team, contributed to the study design and did the statistical analyses. PJD contributed to the study concept and design, assisted with developing the manuscript and critically reviewed the manuscript. LD, NVK and VT all contributed to the study concept and design and critically reviewed the manuscript.

Competing interests

Associate Professor Doherty has a funded research fellowship with the National Institute of Clinical Studies. Accepted 18 September 2006

References


‘Evidence-based implementation’ of paediatric asthma guidelines in a rural emergency department

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Aim: To determine if an evidence-based implementation (EBI) could lead to improved compliance with guidelines for acute asthma in children aged 6–13 years presenting to a rural hospital emergency department.

Methods: Pre-intervention, post-intervention and 12-month follow-up audits were performed to determine the impact of an EBI strategy used to increase compliance with existing asthma guidelines. The pre-intervention audit was conducted from April to June 2004, and follow-up data were collected from 1 September to 30 November 2004. The 12-month follow-up audit was conducted from 1 August to 31 October 2005. All audits were chart reviews. The intervention was an EBI strategy that was developed, then locally implemented, to achieve improved compliance with the emergency department management of paediatric asthma.

Results: There were 51 presentations pre-intervention, 66 post-intervention and 68 at 12-month follow-up with no differences noted in the severity of asthma between the groups. At 12-month follow-up, there were significant increases in the documentation of asthma severity (45% to 96%, P < 0.001), use of salbutamol (32% to 66%, P = 0.012), use of intravenous cetylprednisolone (3% to 6%, P = 0.009), use of ipratropium bromide in mild asthma (31% to 60%, P < 0.001) and use of intermittent asthma management plans (16% to 68%, P < 0.001). There was a reduction in the use of systemic steroids (74% to 53%, γ = 0.251, P = 0.001) and inhaled corticosteroids in at-risk patients (15% to 8%, γ = 0.078). For the seven clinical indicators identified, compliance with the guidelines increased from 47% to 79% (P < 0.001). Positive changes in clinical behaviour occurred immediately and compliance with all seven CIs was 83% immediately post intervention before being significantly increased at 12 months (P < 0.01).

Conclusions: The post-intervention audit identified a low rate of compliance with current asthma guidelines across seven CIs of asthma care. The intervention significantly increased compliance with five of the CIs and for the seven CIs aggregated. Positive changes in clinical behaviour were noted and the gains were sustained at 12 months.

Key words: asthma guidelines, evidence-based implementation, paediatric.

Australia has a high prevalence of childhood asthma with 14–16% of children affected and those children are frequent presenters to the emergency department (ED).1

Asthma is the most common medical cause for hospital admission in children in Australia.1 Evidence-based guidelines for the ED assessment and management of paediatric asthma2 have existed for some time, yet New South Wales (NSW) Health has recently released clinical practice guidelines for paediatric asthma.3 Even though asthma is common and guidelines are available, management does not always comply with guideline recommendations.1

Clinical practice guidelines in an important component in summing up evidence from research, but unless guidelines are successfully implemented, translation of this evidence into clinical practice will not necessarily occur. Translating evidence into clinical practice is difficult4 and remains a major barrier to improving health.1 There is an increasing knowledge base about what implementation strategies are most effective, and some researchers have questioned whether evidence-based implementation (EBI) of evidence-based guidelines is possible.4

Numerous strategies exist for implementing guidelines,3,4,5 with varying success rates and no definitive best strategy for all occasions.6 The evidence base for implementing change in clinical behaviour is often not used, with most implementation studies providing no rationale for the intervention chosen and offering no proof that any change in practice was due to
the intervention. In many studies the intervention is not sufficiently detailed to allow others to reproduce the same methodology. There is evidence that traditional strategies, such as mail outs of guidelines and wall charts, are ineffective. Evidence-based medicine (EBM) is a trial of best available evidence and clinical judgement applied to an individual patient. This can be extrapolated to EDs. That is, an ED is a trial of best available evidence (for implementation of guidelines, for example) judiciously used and applied to an individual department, unit or health service. In the same way that EBM needs to take into consideration the unique characteristics of the individual patient, so too an ED needs to take into account the unique characteristics of a department or hospital. In 2004 the Clinical Excellence Commission (CEC) commenced a pilot project at a number of hospitals across NSW to implement the NSW health clinical practice guidelines for pediatric asthma. The aim of our study was to determine if an evidence-based approach to implementation could improve compliance with these guidelines in a rural referral hospital ED.

Methods

An EBI strategy was used to implement guidelines for the ED management of pediatric asthma. Data were collected and compared at baseline, post intervention and 12 months for all children aged between 1 and 15 years inclusive, who presented to Tamworth Rural Referral Hospital ED with asthma. The data collection periods were 1 April to 30 June 2004, 1 September to 30 November 2004 and 1 August to 31 October 2005. The intervention commenced in August 2004. Statutory approval to implement the project within NSW Health facilities was granted by the CEC.

Tamworth Rural Referral Hospital is a 236 bed and is the major rural referral hospital in the New England area. The ED is a mixed adult/pediatric department with an annual census of about 37,000 patients, of which 10,000 are children, and an admission rate of 14%. It has a specialist emergency physician cover 24 h per day with occasional 2 h per day cover. The remaining medical staffing is provided by junior medical officers, registrars and house officers who rotate through the team. The spectrum of staffing is common to many EDs in rural and urban areas. Nursing staff are all dedicated to the ED and there are no allied health services available in the department.

An EBI was devised and this has been detailed previously. Features of this implementation were:
1. Identifying evidence practice gaps (see Box 1). These evidence practice gaps served as our clinical indicators (CIs) for the study.
2. Identifying barriers to change at the level of the patient, individual doctor or nurses, the ED team and the organisation and processes within the ED.
3. Reformulating guidelines for the management of acute pediatric asthma into a single, useable format, consisting of a single-sided A4 tick-box guideline. This was a working document (see Appendix I) and incorporated into the medical record at triage.
4. The use of reminders. Methods used included the guideline itself as a reminder in the notes, senior staff informing the use of the guidelines during clinical shifts, reminders during formal education sessions and notices placed on the walls and notice boards within the department.
5. Audit and feedback were posted as aggregate data in the department tea room at about monthly intervals; this acted also as a reminder.
6. Education sessions were arranged to coincide with routine department teaching and updates about the project were provided informally at the end of other sessions. Nursing staff were educated about the project during the afternoon handover each weekday in the week before the guideline was introduced.
7. An implementation team, comprising the Director of the Department, the Nursing Unit Manager, a clinical nurse specialist, a clinical nurse consultant and a senior emergency physician, oversaw the project.
8. Senior medical and nursing staff were used as local opinion leaders to reinforce the relevance of the guidelines to junior and new staff and to encourage clinicians to adhere to the strategies recommended in the guidelines.
9. Information about the guidelines in the written orientation package and/or on notes inserted that new and locum doctors received.

Baseline audits established rates of compliance for the seven CIs for pediatric asthma as outlined in Box 1. All data were extracted during a pre-intervention data collection period and all data were extracted by the lead author. For all data collection periods the Emergency Department Information System was searched to identify all patients admitted and discharged with an ICD-9 diagnosis of asthma. Data for an individual CI (e.g. the prescribing of corticosteroids) were excluded if the patient was already on the treatment before presenting to the ED. All data were entered into a de-identified database. Subsequent audits used the same methodology as the pre-intervention audit.
coccot was if the only feature was pulse rate, the reviewer had to make a decision based on the degree of tachycardia, amount of previous salbutamol use and any other factor which may have influenced pulse rate.

The a priori chi-squared test sample calculation resulting in a total sample size of 100 was based on the following parameters: effect size = 0.5, alpha = 0.05, and power = 0.89. Based on annual attendances with asthma, it was anticipated that 3-month data collection periods would achieve these numbers. Data for all seven CIs were subjected to chi-squared testing (version 3.1.3). In cases where at least one expected cell value was <5, Fisher's exact tests (two-tailed) were used. Aggregate data, representing the sum of compliance for the seven CIs, were also subjected to chi-squared testing.

Results

There were 31 patients pre-intervention, 66 post-intervention and 68 at 12-month follow-up. The grading of severity is shown in Table 1. The gender ratio, mean age and age range are shown in Table 2. For all three phases of the study, there was no significant difference in the ratio of males to females in the three groups (P = 0.324, χ² = 1.0, 1 degree of freedom).

Given the low number of patients with severe asthma, statistical analysis of assessment of severity compared mild asthma with moderate-severe combined. There was no significant difference in the severity of asthma in the pre-intervention, post-intervention or 12-month follow-up periods (P = 0.348, χ² = 2.29, 2 degrees of freedom).

Table 1 shows compliance with the seven CIs for the three time periods and also aggregate compliance across the seven indicators.

From post-intervention to 12-month follow-up, there was no significant difference in compliance with the guideline for the aggregated CIs (P = 0.145, χ² = 2.16, 1 degree of freedom).

There were no significant changes in compliance with individual CIs in this time, except for the provision of short-term asthma management plans (STAMPs), which had statistically significant reduction in use (P = 0.014, χ² = 3.17, 1 degree of freedom).

Discussion

These results demonstrate that an EBI can change clinician behaviour and significantly increase compliance with guidelines. Meta-analyses demonstrate that attempts to increase guidelines compliance usually yield changes in the order of 10%.

Changes in compliance were of much greater magnitude in this study. The intervention focused more on ED processes and organization than on individual clinicians. Evidence exist that targeting individual clinicians alone is of limited value in a complex environment such as a busy ED, and that the practice environment itself also needs to be addressed.

One of the limitations in targeting individual clinicians in our setting is that most of the medical staff are junior doctors rotating through the term in 10- to 12-week blocks, or locum staff working for periods as short as 1 week.

In addition to the magnitude of the overall improvement, the intervention also resulted in significant improvement for five of the seven individual CIs. The intervention produced immediate changes in practice, which were sustained at 12 months, for the seven CIs in total. The provision of STAMPs was the only individual CI that had a significant increase in compliance from post-intervention to 12-month follow-up.

### Table 1

<table>
<thead>
<tr>
<th>Presentations and assessment of severity</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention (n=31)</td>
<td>56 (17%)</td>
<td>24 (7%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Post-intervention (n=66)</td>
<td>42 (65%)</td>
<td>21 (32%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>13-month follow-up (n=68)</td>
<td>55 (79%)</td>
<td>24 (34%)</td>
<td>2 (3%)</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Gender ratio and age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention</td>
<td>37</td>
<td>19</td>
<td>56</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>68</td>
<td>21</td>
<td>89</td>
</tr>
<tr>
<td>12-month follow-up</td>
<td>48</td>
<td>18</td>
<td>66</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Domain</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>12-month follow-up</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation of severity</td>
<td>29/100 (35%)</td>
<td>63/100 (95%)</td>
<td>61/100 (80%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Symmetry</td>
<td>9/100 (0%)</td>
<td>50/100 (50%)</td>
<td>21/100 (21%)</td>
<td>0.012</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>29/100 (35%)</td>
<td>49/100 (50%)</td>
<td>4/100 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypoallergic</td>
<td>11/100 (11%)</td>
<td>10/100 (10%)</td>
<td>1/100 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>steroids</td>
<td>5/100 (5%)</td>
<td>4/100 (4%)</td>
<td>1/100 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>STAMPs</td>
<td>7/100 (7%)</td>
<td>6/100 (6%)</td>
<td>2/100 (2%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Antibiotics prescribed</td>
<td>6/100 (5%)</td>
<td>10/100 (10%)</td>
<td>3/100 (3%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*P-value is from pre-intervention to 12-month follow up. STAMP: short-term asthma management plan.
Notwithstanding, the 12-month compliance was still significantly above baseline results.

The A4 guideline adhered to principles that are known to increase compliance with guidelines, these being compatibility with existing beliefs, simplicity, reducing (or not increasing) workload, being well-validated, being from a respected source and requiring fewer new skills to be learned. The guideline was commenced at stage 1 and there is evidence that paediatric guidelines have been successfully implemented based on the existing problem in EHRs and evidence that doctors prefer to have guidelines accessible on the front of the chart. Reminders, audit and feedback and education have been shown to be the most successful drivers of change and all three were used as part of the intervention, with reminders taking many forms.

Senior clinical staff supported the change and acted as opinion leaders, the evidence for opinion leaders use was considered relevant to this study because of the large number of rotating junior and senior medical staff with relatively few senior medical staff. In this context the leadership role of senior doctors was felt to be of importance.

While there was no control hospital in this study, our intervention has been shown to be successful in controlled trials for adult asthma in a variety of rural hospitals. This study, utilising historical controls, demonstrates the effectiveness of the clinic in a different patient population and confirms our previous work.

The baseline data highlight that even for common conditions such as asthma, the translation of knowledge, based on good evidence, and available in a number of reputable guideline publications, is less than optimal, with only 47% guideline compliance rate at the commencement of the study. Similar compliance rates for some of these indicators have been documented in other hospitals and in a national study of asthma management.

There is sound evidence to support the clinical management encouraged by the guideline. Spirometry is preferred over peak flow rate (PFR) measures for diagnosing asthma and can be reliably performed by children over the age of 7 years. There is evidence to support the use of spacers, and the reduction of pretreatment to severe episodes in school-aged children only.

A short course of systemic corticosteroids following an acute attack has been shown to reduce symptom duration and representation rates, and is preferable to inhaled steroids. There is also evidence that patients need written instructions and advice for the first 24-48 h after an acute asthma attack, and a readily available pre-packaged SABA may have facilitated the increased compliance with this indicator. There is little role for antibiotic use in acute asthma, and while antibiotics use dropped from 15% to 6%, this did not reach statistical significance. The lack of statistical significance for this indicator may be due to the relatively low rates of prescribing, and hence good compliance to begin with.

Limitations

This study has a number of limitations. In the pre-intervention phase only 45% of patients had the severity of their acute asthma attack documented in the notes and a retrospective assessment was made using the National Asthma Council criteria. Retrospective assessment of severity from the clinical record even if based on sound criteria, remains a limitation of this study. Previous studies have demonstrated inconsistency of severity assessment of asthma among emergency physicians. Kappa analysis was not performed for this study but was for a parallel study in adults, and this confirmed that this method of retrospective review made an adequate assessment of severity.

The lack of a control hospital does not allow us to comment on any confounders. In a concurrent study on adult asthma, a rural district hospital was used as a control. This rural district hospital was not used as a control for this study as it was also part of the CEC pilot project. It is of interest that this hospital made significant improvements in compliance with paediatric asthma guidelines (M Crispshank, pers. comm., 2006), yet there was no change in compliance with the same CI for adult population.

The principal of an EBI is that the evidence for change is tailored to the uniquely individual department. Hence this intervention was designed specifically for this hospital EB. The intervention, with local variation, may be applicable to other rural and metropolitan EBI with similar characteristics, though this cannot be inferred from this study alone.

The initial audit demonstrated that compliance with some CIs including metered-dose inhaler (MDI) use, assessment of severity and SABA was poor, and there is evidence that improvement is greater when the starting base is lower. These results cannot therefore be extrapolated to departments that are performing better in these areas.

The outcomes measured are all surrogate outcomes and there was no attempt to demonstrate decreased admission rates, length of stay, representations or symptom duration. Nevertheless, evidence supports our view that these surrogate outcomes lead to clear clinical benefits for example, a short course of systemic corticosteroids will reduce admission rates, representations and symptom duration.

Conclusions

This study demonstrates that an EBI can significantly improve compliance with guidelines with the potential to achieve much greater gains than in many previously published quality improvement (QI) projects. The intervention was successful in improving compliance with five of the seven CIs and the gains were maintained at 12-month follow-up.

Acknowledgement

Associate Professor Doherty completed this research while holding a funded research fellowship with the National Institute of Clinical Studies.

References

3 Therapeutic Guidelines: Respiratory; Version 3; Melbourne: Therapeutic Guidelines Ltd, 2005.


Appendix 1

Hunter New England Area Health
PAEDIATRIC ASTHMA MANAGEMENT IN EMERGENCY DEPARTMENT

INITIAL ASSESSMENT (Tick the feature)

IF ACUTELY DISTRESSED GIVE O2 AND SALBUTAMOL NOW

<table>
<thead>
<tr>
<th>SYMPTOMS</th>
<th>MILD</th>
<th>MODERATE</th>
<th>SEVERE AND LIFE-THREATENING</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC</td>
<td>Normal</td>
<td>Normal</td>
<td>Agitated, confused, drowsy</td>
</tr>
<tr>
<td>Accessory muscle use</td>
<td>No to minimal</td>
<td>Minimal to Moderate</td>
<td>Moderate to excessive</td>
</tr>
<tr>
<td>Pulse rate</td>
<td>Normal for age</td>
<td>Tachycardia</td>
<td>Severe tachycardia or bradyarrhythmia</td>
</tr>
<tr>
<td>Talk in</td>
<td>Absent</td>
<td>Absent</td>
<td>Words unable to speak</td>
</tr>
<tr>
<td>Central cyanosis</td>
<td>Absent</td>
<td>Moderate-loud</td>
<td>Likely to be present</td>
</tr>
<tr>
<td>Wheeze intensity</td>
<td>Variable</td>
<td>40-60%</td>
<td>Moderate-Sed/fainting aura</td>
</tr>
<tr>
<td>FEV1 (%) predicted</td>
<td>&lt;60%</td>
<td>40-60%</td>
<td>&lt;60% or Unable to perform</td>
</tr>
<tr>
<td>Peak expiratory flow rate</td>
<td>&lt;60%</td>
<td>40-60%</td>
<td>&lt;60% or Unable to perform</td>
</tr>
<tr>
<td>SpO2 on presentation</td>
<td>&lt;90%</td>
<td>90-94%</td>
<td>&lt;90% cyanosis may be present</td>
</tr>
</tbody>
</table>

Triage nurse: Severity Score: [ ] Mild [ ] Moderate [ ] Severe
Decision: Severity Score: [ ] Mild [ ] Moderate [ ] Severe

INITIAL MANAGEMENT - ASSESSMENT OF ACUTE ATTACK
- If severe or life-threatening - notify senior doctor immediately

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>MILD ATTACK</th>
<th>MODERATE ATTACK</th>
<th>SEVERE &amp; LIFE-THREATENING ATTACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2</td>
<td>As required</td>
<td>Yes</td>
<td>Continuous SpO2 monitor</td>
</tr>
<tr>
<td>Salbutamol</td>
<td>&lt;20mg 3 puff MDI/peel OR 2.5mg neb OR 1.25 mg iv</td>
<td>For Moderate 3 doses of above Q 20 minutes</td>
<td>Continuous nebulised therapy. Consider IV infusion</td>
</tr>
<tr>
<td>Amount</td>
<td>No</td>
<td>No</td>
<td>Nebulise x 3 O2 20 minutes (200mg 250mg 250mg)</td>
</tr>
<tr>
<td>Steroids</td>
<td>Prednisone 1 mg/kg/day outpatient course 5-7 days</td>
<td>Hydrocortisone 4mg q8h</td>
<td>Intravenous 1 mg/kg q6h 8-hour infusion course</td>
</tr>
<tr>
<td>CSF</td>
<td>Not necessary unless focal signs present</td>
<td>Necessary if no response to initial therapy or suspect pneumothorax</td>
<td></td>
</tr>
<tr>
<td>Arterial blood gases</td>
<td>Test not necessary</td>
<td>If initial response poor</td>
<td>Yes, if life-threatening</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Not routinely required</td>
<td>Consult therapeutic guidelines (pink book) before prescribing</td>
<td></td>
</tr>
<tr>
<td>Disposition</td>
<td>Home with list in ANP Salbutamol 0.4mg 4 hourly</td>
<td>If after treatment and signs of CSF they have features of moderate asthma admit. If improved discharge as per mid.</td>
<td></td>
</tr>
</tbody>
</table>

REAHIS Asthma Emergency Department Assessment and Management Plan - July 2018

96
O R I G I N A L  R E S E A R C H

Use of an 'evidence-based implementation' strategy to implement evidence-based care of asthma into rural district hospital emergency departments

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Rural and Remote Health 6: 529. (Online). 2006

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A B S T R A C T

Introduction: To determine if an evidence-based implementation (EBI) could lead to the successful implementation of evidence-based care for adult asthma in all rural district hospitals.

Method: A controlled trial involving eight rural hospitals (four each in the study and control groups) was conducted. Retrospective pre-intervention audits were conducted at all eight hospitals for 7 months (1 January 2004 to 31 July 2004) and evidence-practice gaps were identified. An EBI was then used to implement established guidelines for the management of asthma in the study hospitals. Post-intervention audits were then performed over a period of 7 months (1 October 2004 to 31 April 2005).

Results: There were 52 presentations of asthma in the study hospitals in the pre-intervention phase and 47 post-intervention phase. The corresponding numbers for the control hospitals were 46 and 42 respectively. There were no statistically significant differences in the severity between the groups. Following the EBI there were significant improvements at the study hospitals for the documentation of severity (8% to 63%, p 0.000), use of sociochemistry (13% to 62%, p 0.001) and the use of written short-term asthma plans (7% to 26%, p 0.005). There was a decrease in the use of intravenous sedation in mild asthma (44% to 20%, p 0.02) and decrease in the use of systemic steroids (61% to 72%, p 0.235) and no change in prescribing antibiotics for stable
patients with asthma (21% to 21% p = 0.956). There was no significant change in practice at the central hospitals except for a decrease in the use of systemic steroids (46% to 31%, p = 0.011). For the six clinical indicators, there was a significant increase in compliance with guidelines at the study hospitals (25% to 62%, p < 0.001) but no change at the central hospitals (31% to 31%, p = 0.307).

Conclusion: The pre-intervention audits demonstrated low levels of compliance with asthma guidelines across six clinical indicators. An EBI significantly improved compliance across these six indicators, and no improvement was noted in the central hospitals. This study demonstrates that an EBI can alter clinical practice in small rural district hospitals.

Keywords: asthma, emergency department, evidence-based implementation

Introduction

Australian adults have a prevalence rate of asthma of 10.12% which is one of the highest in the world. In addition, hospitalisation rates are highest among Aboriginal and Torres Strait Islanders and in rural and remote areas. Evidence-based guidelines for asthma exist and are the basis of New South Wales (NSW) Health’s guidelines for the management of acute asthma. Despite this, there is evidence that these guidelines are not always followed. Developing guidelines is an important component in summarising evidence from research, but unless there is a successful implementation process, the translation of this knowledge into clinical practice will not necessarily occur. Translating evidence into clinical practice is difficult and remains a major barrier to improving health. There is an increasing knowledge base about what implementation strategies are most effective, and some researchers have questioned whether evidence-based implementation (EBI) of evidence-based guidelines is possible.

Increasingly, there has been a focus on equity of access and quality of health care in the rural environment. Some advocate that small rural hospitals should become centres of quality health care and training. In the vast majority of cases of asthma, and many other emergency department (ED) presentations, the achievement of best practice does not require access to the additional resources usually only found in large metropolitan hospitals. Therefore, best practice for the majority of asthma presentations is achievable in even the smallest rural hospital. There is evidence too that, despite barriers, rural OSH view EBM positively and support a regional approach to asthma management based on National Asthma Council (NAC) guidelines.

With regard to the implementation of best practice, there is little evidence to indicate what strategies are most likely to be beneficial in rural district hospitals in Australia, let alone rural district emergency departments (ED). This article will report the results of an EBI, adapted from an implementation strategy at a rural referral hospital, designed to improve ED assessment and management of acute asthma in adults.

The aim of this study was to determine if an evidence-based approach to implementation of asthma guidelines would translate into improved compliance with evidence-based care for acute asthma in adults in a number of small, rural district EDs.

The lead author was an emergency physician working clinically within the Area Health Service that the study and central hospitals are in, and had for many years performed retrievals, provided advice and been involved in accepting the transfer of patients from these hospitals.

Methods

A pre-intervention audit of asthma management (assessment and treatment) was conducted in eight rural district hospitals. Audit was performed by the author for these hospitals in
Rural-and-Remote-Health

Each group and by senior nurses, trained in the use of the data collection forms, at all other two hospitals. From their audits evidence practice gaps (EPG) were identified. All identified patients aged 14 and over were included. Audit data was entered into a de-identified database.

Pairs of hospitals were matched based on size, and one randomly allocated to the study group with the other serving as a control. The sample size required to detect a 30% improvement in compliance with a clinical indicator, with a level of significance of 0.05 and a power of 0.9 was 26 patients. Based on estimates of attendance with asthma for these hospitals, 7 months of post-intervention data were collected from 1 January to 31 July 2004 and 7 months of post-intervention data were collected from 1 October 2004 to 30 April 2005. The intervention at all four study hospitals occurred between August and September 2004. The study hospitals were subject to an ED notified below. The control hospitals had no additional intervention to help implement established guidelines for asthma. The National Asthma Council and Respiratory Therapeutic Guidelines have been available for years and form the basis of the NSW Health guidelines, which have been disseminated to hospitals throughout NSW. Dissemination of guidelines without a dedicated implementation plan is a common method used by health departments to improve knowledge among clinicians.

All eight hospitals were staffed by GP visiting medical officers (VMOs) with no dedicated or in-house medical staff. Each of the EDs registered between 2000 and 3000 patient visits per year, although the previous ED systems did not allow differentiation between ED presentations and outpatient visits. The EDs were staffed by nurses who also had to fulfill other duties throughout the hospital and wards, were not full-time ED nurses. The eligible towns were located between 50 km and 200 km from the nearest base referral hospital and serviced populations between 1000 and 14000 people. All towns had a rural, remote and metropolitan area (RRMA) rating of 5.

There was no standard ED data collection system across the eight hospitals. Admitted patients were identified by ICD9 coding. Non-admitted patients were identified by a manual search of the hand-written ED attendance register. Documented attendances for asthma, 'wherever, 'short of breath' and similar phrases were reviewed. Only those patients with an ED diagnosis of asthma were included in the database. Data for all patients identified were included in the study. For an individual clinical indicator (e.g. the prescribing of emtrastine) were excluded if the patient was already on the treatment prior to presenting to the ED.

When assessing the severity of asthma, the reviewer made an assessment of severity based on the clinical record and in consultation with the features of severity outlined in the NAC asthma management handbook. Any one feature of moderate severity led to classification as moderate, and any one feature of severe led to classification as severe. The only feature was if the only feature was pulse rate; the reviewer had to make a decision based on the degree of hypoxia, amount of previous ventolin use, and any other factors which may have influenced pulse rate.

Data for all indicators in both the study and control hospitals were subject to X² testing (Epi info vers 2.2, CDC, Atlanta, GA, USA). In cases where at least one expected cell value was less than 5, Fisher exact tests (two-tailed) were used.

While this was primarily a quality improvement process, it did involve assessing and reviewing patient records at other public hospitals and, hence, ethical approval was sought and gained from the New England Area Health Service (NEAHS) Ethics Committee.

An evidence-based approach to implementation was devised and this has been extensively detailed in a previous article. The main points of the implementation, including revisions to suit the rural district environment, involved as follows.
Identifying evidence-practice gaps

An initial multi-identified area where ED practice deviated from evidence-based recommendations. These EPO were discussed with medical, nursing and administrative staff at the study hospitals to determine which areas to attempt to address. The areas identified are listed in the Results section.

Identifying barriers

Identifying barriers to change at the level of the patient, individual doctor or nurse, the ED team and the organisation and processes within the ED. These barriers were identified at each study hospital. Barriers were different from those identified at a rural referral hospital and the specific differences in reasons for changes to the implementation strategy are discussed in more detail in the Discussion.

Guideline development

Reformulation of the NAC guidelines for acute asthma into a simple, usable format, consisting of a single-sided A4 template. The guidelines became part of the medical record and was commenced at stage three. Discussions at each hospital modelled comment and recommended variations to the guidelines, based on local issues.

Reminders

By being incorporated into the medical record, the guidelines served as a reminder. During the implementation and follow-up phases, the nurses visited each study hospital on two occasions to talk to nursing staff and once to talk to medical staff. A senior nurse at each hospital was also encouraged to remind staff about the guidelines.

Education

Education sessions were arranged with medical and nursing staff at the time of implementation, focusing on barriers to change, evidence for asthma management and the guideline itself. As part of the implementation, all the doctors were invited to read a pre-written material of two draft papers, subsequently published, on the history of and arguments for and against evidence-based practice.

Audit and feedback

Presentations for acute asthma at any individual hospital was low and hence, auditing only occurred once or twice at each hospital during the seven-month follow-up period. Given this, audit and feedback was not used as a strategy.

Implementation team

A specific implementation team at each hospital was not possible due to staffing levels. Most contact between the author and the study hospitals was via one senior clinical nurse at each hospital.

Results

Evidence-practice gaps

Six EPO were identified and targeted for change. These were:

1. Lack of formal documentation of severity (mild, moderate or severe) in the clinical record
2. Lower rates of oxygen therapy for the management of acute attacks
3. Overuse of ipratropium for mild asthma
4. Underutilisation of systemic corticosteroids
5. Lower utilisation of written short-term asthma management plans (STAMP)
6. Overuse of antibiotics for acute asthma

Total presentations

For the study hospitals there were 51 patients in the pre-intervention phase and 47 in the post-intervention phase. For the control hospitals, the number of presentations were 47 and 42, respectively. At the study hospitals, to detect a
change in compliance of 30% with a level of significance of <0.05, the sample size gives a power of 0.84. The grading of severity is shown (Table 1).

Given the low number of presentations with severe asthma, statistical analysis of assessment of severity compared mild asthma with moderate-severe asthma. From the pre- to post-intervention period, there was no significant change in the rate of mild versus moderate-severe asthma in the study hospitals ($p=0.5, \chi^2=0.1, 1$ degree of freedom) or in the control hospitals ($p=0.3, \chi^2=1.1, 1$ degree of freedom).

Table 2 shows the pre- and post data for both the study and control hospitals for all indicators combined.

Statistically significant improvements were noted for the following clinical indicators at the study hospitals:
1. assessment of severity increased from 8% to 62%
2. symptoms increased from 12% to 62%
3. symptoms or peak flow rate use increased from 31% to 68%
4. use of STAMP increased from 9% to 20%
5. the aggregate of all use indicators from 36% to 62%

There was an increase (non-statistically significant) in use of systemic corticosteroids from 61% to 72%, including an increase from 59% to 81% for the moderate-severe subgroup.

There was a non-significant decrease in intravenous use for mild asthma in the study hospitals from 44% to 39%. Intravenous use in mild asthma was largely confined to one medical practice at one of the study hospitals. If data from this study hospital are removed, then the rate of intravenous use for mild asthma in the other three hospitals has fallen from 13/17 (45%) to 16/34 (47%) ($p<0.05$, Fisher exact test, two-tailed).

There was no change in antibiotic prescribing for adult patients with asthma.

There were no significant changes in practice at the control hospitals except a significant decrease in systemic corticosteroids use from 46% to 21% ($p=0.001$). At the control hospitals systemic corticosteroid use for the moderate-severe group fell from 69% to 50%, although this did not reach statistical significance.

Discussion

The ultimate aim of any quality improvement (QI) project is to change clinician behavior for the better. A concept that emerged during the implementation process, and from meetings with clinicians, was the concept of intention. The medical intention is to change people's habits and ideas towards consulting or prescribing. Successful implementation of change requires the targeted clinicians to believe in the evidence for and the value of the change. The evidence-based approach to implementation was designed to try and achieve this aim.

QI in rural areas

Criticals of QI projects include that there is often no rationale for the method of implementing change, and that they generally have poorly described methods. In addition, many QI projects don't provide any evidence that any resultant change is due to the intervention and not some other factor. The study was designed to address some of these limitations and has demonstrated that an EDI, can lead to significant improvements in compliance with evidence-based guidelines for asthma. Further research suggests that attempts to increase compliance with guidelines can expect to yield changes in the order of 10%. For some of the areas targeted for improvement the changes were of much greater magnitude in this study.
The implementation did not confine itself to the individual because there is evidence that targeting individual clinicians alone is of limited value in a complex environment such as an ED, and that the practice environment itself also needs to be addressed. The intervention used in the study targeted not only individuals, but also processes within the ED and the organizational aspects of the departments.

The guideline was formulated to address the principles that are known to increase compliance with guidelines, these being compatibility with existing beliefs, simplicity, reducing (or not increasing) workload, being well validated, being from a respected source and requiring fewer new skills to be learned.

Reminders and education, especially outreach education, have been shown to be among the most successful strategies for change, and both strategies were used as part of the intervention.

The lead author visited sites, discussed evidence, discussed the guidelines and advocated compliance with the guidelines. In doing so, the lead author became a part of the implementation process as a knowledge broker, or a link between research evidence and clinical practice. There is evidence that such a role is crucial in implementing change.
Uniqueness of rural medicine

There are a number of factors that make the rural environment different. Nearly half of the rural population (44%) live in an area that has a shortage of doctors8. In addition, 30% of rural Australians account for only 20% of Medicare rebates and are served by only 15% of the medical workforce9.

Those doctors who do provide services to rural district hospitals are usually GP VMOs or GP registrars, and attend to patients in the ED on an on-call basis. This is unlike regional referral hospitals where a hierarchy of full-time staff, from specialists trained in emergency medicine, to registrars, through to junior doctors and locums, practice. Attempts were made to visit each VMO either in their practice or at a scheduled hospital meeting but not every VMO was willing or able to be interviewed for the study. Difficulties meeting each VMO and documenting the implementation and outcomes behind the desired clinical behaviour was a significant impediment to the implementation process and may have impacted on the degree of change. Rural GPs have identified barriers to practicing EDM that includes environmental barriers such as remoteness, professional isolation, workload and lack of evidence 'at hand'10. The same GPs have identified possible solutions to improve access to EDM11 and these solutions include better access to clinical practice guidelines, medical direction and 'traveling road shows', all of which were components of this intervention.

Nursing staff at rural district hospitals are not full-time, dedicated ED nurses and within the same shift they may work in a number of different areas of the hospital. This again is different to staff in regional base hospitals whose nursing staff are generally working in the ED only; many of them with extensive emergency nursing experience. The implementation for the nursing staff included Power Point presentations on evidence-based medicine, the NAC guidelines and the planned guideline use. Asthma nurse educators were also involved in providing education on spirometry use and asthma management.

The ED teams and organisation also differ in rural district hospitals. The numbers of presentations of any condition are much lower which means there is a lower frequency of exposure to any condition, such as asthma and, therefore, less opportunity to use and become familiar with the guidelines. In these hospitals, there are pathways in place and so it is more difficult to establish a 'culture' of guideline use. Following on from this, there is often no obvious physical structure or place where the guidelines are kept and they are filed with other sheets of paperwork. Despite attempts at addressing these issues, during site visits to two different study hospitals during the follow-up phase, the guidelines could not be readily found.

During the timeframe of this study a number of other projects were occurring across the area health service including both study and control hospitals. These included a pilot project of patient education guidelines, including asthma, being run by the Clinical Excellence Commission (CEC), a chronic care collaborative for chronic obstructive pulmonary disease and an extensive education campaign by clinical nurse specialists including parameter use and asthma management. All these projects had the potential to impact on the ED management of asthma.

Improvements in compliance

There is evidence to support the six RPO identified in this study. Assessment of severity is self-evident because asthma guidelines7 have different treatment strategies for different degrees of severity. The documentation of severity improved by 56% in the study hospitals with no change in the control group. Follow-up documentation of severity was generally associated with the guideline not being found in the medical record.

Spirometry is the preferred method for diagnosing and monitoring the progress of asthma12 and has been identified as an area of need with respect to ongoing education by GPs13. Very significant improvements in spirometry use were noted in the study hospitals. Despite other initiatives occurring across the area that had the potential to increase
Rural-and-Remote-Health

The International Electronic Journal of Rural and Remote Health Research, Education Practice and Policy

symptom rate, there was no significant improvement in symptom rate in the control hospitals.

In severe asthma, ipratropium significantly improves symptom and admission rates, but these benefits have been demonstrated for moderate asthma. An evidence-based review found ipratropium to be beneficial for children or adults with acute severe asthma but of no benefit in those with mild to moderate asthma. Even though ipratropium is commonly used, Australian guidelines recommend that it not be used for mild asthma and list it as 'optional' for moderate asthma.

In this study there was a decrease in ipratropium use for mild asthma at the study hospitals of 14% compared with a 9% reduction in the control hospitals; neither group reached statistical significance. However, as noted in the Results, ipratropium use after the intervention was confined largely to just one study hospital and if the data from this hospital are removed, then significant reductions occurred at the other three.

A short course of systemic steroids reduces readmissions, decreases beta-agonist use and decreases admission rates in acute asthma, especially with more severe asthmas. The increase in use of systemic steroids in the study hospitals was 11% overall but 21% for the moderate to severe group. Neither figure reached statistical significance, but the 81% figure for the moderate to severe group is higher than the national average.

Unexpectedly there was a significant decrease in systemic corticosteroid use at the control hospitals from 49% to 21%, including a non-significant decrease for the moderate to severe group from 69% to 50%. While not specifically studied, there was an anecdotal noted increase in inhaled corticosteroids at the control hospitals with many patients receiving inhaled but not oral corticosteroids actually. It is possible that, in the absence of evidence-based guidelines, other external factors have influenced the prescribing practice. While there may be some evidence that high dose inhaled steroids alone are as effective as systemic steroids for mild asthma, this still needs to be clarified. Categorize steroids have determined that there is insufficient evidence that inhaled steroids are as effective as, or provide any additional benefit above and beyond systemic steroids.

The intervention utilized a simple preformatted STAMP for the decision to complete and give to the patient on discharge and the 37% increase in use was statistically significant, through clinically modest. Rural patients were written instructions and advice for the first 24-48 hours after an acute asthma attack.

The role of antibiotics in the treatment of acute asthma is difficult to assess from the current literature; however, the general consensus is that most infectious triggers of asthma are viral. This ERH did not alter the role of antibiotic prescribing.

Overall, the compliance for the six clinical indicators increased from 30% to 81% at the study hospitals with no change in the control hospitals. These data highlight that despite well respected guidelines being available, and despite asthma being a common disease, compliance with best practice remains low. This emphasises the importance of knowledge translation.

Limitations

There are a number of limitations to this study. The desired sample size of 88 patients was not met in the follow-up period with data for only 67 patients being recorded. For a level of significance of 0.05, this reduces the power to 0.64, which is still adequate for a study of this nature. The overall, aggregated increase in compliance with the six clinical indicators was 14%, which was less than the targeted improvement of 30%, although still in excess of the 10% average described in the literature.

In the pre-intervention phase, only approximately 10% of patients in the eight hospitals had formal documentation of severity in their notes. The initial audit, therefore, had to make an assessment of severity based on the clinical record.
with reference to the NAC "initial assessment of severity of acute asthma in adults" table in the Asthma management handbook. While a Kappa analysis was not performed for this phase of the study, it has been performed in a parallel study, yielding a result of 0.26, which confirmed that this method of retrospective review is capable of making an adequate assessment of severity. The assessment of severity is important because evidence-based treatment for acute asthma varies depending on the severity. Nevertheless, the retrospective assessment of severity, even if based on sound criteria, remains a limitation of this study.

The initial audit demonstrated that compliance with some clinical indicators including assessment of severity, symptom and STAMP was poor, and there is evidence that improvement is greater when the starting base is low. These results cannot, therefore, be extrapolated to departments that are performing better in those areas.

The outcome measures are all surrogate outcomes and there was no attempt to demonstrate decreased admission rates, adverse events, length of stay, representations or symptom duration. Nevertheless, evidence supports our view that these surrogate outcomes lead to clear clinical benefit, for example a short course of systemic corticosteroids will reduce admission rates, representations and symptom duration [30].

As noted, the lead author became an integral part of the implementation process. This may limit the applicability of this approach, because other individuals looking to see the EBI in other contexts will have different personal and professional qualities, interpersonal skills and interpersonal relationships with their target audiences, which may help or hinder the process. Once the implementation was complete, the ability of the lead author to maintain this role was diminished and this may have an impact on the sustainability of those changes.

A final limitation is that no attempt was made to determine how prepared any of the eight hospitals in the study were to carry out change successfully. It was beyond the capacity of the study to conduct an assessment such as the Change Achievement Success Indicator [30].

Hence, it is possible that by chance the study hospitals as a group were more or less susceptible to change and that if the two groups had been reversed the results may have been different.

A qualitative study is being planned to follow up which aspects of implementation were the most crucial to the success of this strategy, and a follow-up study to determine if the changes have been sustained is also planned.

Conclusion

This study has demonstrated that an EBI can significantly improve compliance with evidence-based guidelines, with the potential to achieve much greater gains than in many previously published QI projects. The study design has also demonstrated that the changes in clinical practice were more likely due to the EBI rather than some other confounding variable.

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References


Chapter 8: Audit in Quality Improvement Research

The quantitative papers in this thesis constitute quality improvement research and audit is an important component of this. Due to a concurrent project, the CECP, the study hospital used for paediatric asthma changed its data collection for asthma attendances during the study period.

The data in this thesis was collected by manual audit. For the paediatric study, baseline and immediate follow-up data were collected by manual audit. Prior to 12 month follow-up data the ED started using automated teleform to report CECP data. For consistency, manual audit was still performed for the 12-month follow-up period and it is this manually collected data that is reported in this thesis.

As a result two sets of data were available for the same patient group, one collected manually and one collected by teleform. This provided a unique opportunity to examine the relationship between traditional manual audit and automated data collection forms. This paper reports those findings.
Automated versus manual audit in the emergency department

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Abstract

Purpose: The purpose of this paper is to compare data collected by automated form processing with manual data collection for clinical indicators (CI) in paediatric emergency medicine.

Design/methodology/approach: Paediatric patients presenting with hypothermia, head injury and abdominal pain at Tamworth Hospital were identified by CEDP coding and a traditional manual audit was performed by two data collectors. Data were collected on a total of 50 CIs from these five illnesses. Manual audit data were then compared to information collected for the same patient population using TelEform™, an automated form processing (AFP) system that has been employed for over two years.

Findings: TelEform™ data were only available for 24 patients compared to information for 372 patients identified by CEDP coding and manual audit. TelEform™ data overestimated compliance with clinical guidelines by 27 percent giving an overall departmental agreement with CIs of 80.5 percent compared to 59.5 percent in the manual audit. Additionally, manual audit demonstrated that when the clinical guideline was incorporated into the clinical record, compliance was 82.5 percent compared to 53.3 percent when it was not.

Originality/value: The single center study demonstrates that data collected by AFP systems such as TelEform™, overestimate emergency department performance regarding CI compliance. Dependent data collection tools need to establish relationships between such data and data collected via more traditional auditing methods.

Keywords Data analysis, Auditing, Accident and Emergency, Australia

Paper type Research paper

Introduction

Implementing clinical practice guidelines (CPGs) at Tamworth Rural Referral Hospital Emergency Department (ED) has been an effective means of increasing evidence-based practice (Doherty et al., 2006a; Doherty, 2007; Stevens, 2007). Paediatric CPGs (NSW
Health, 2007) were developed by the Clinical Excellence Commission (CEC) during the statewide Children's Emergency Care Project (CECP). These CPGs were implemented in the ED and a concurrent strategy was developing an automated data collection form, TELEform™, to be completed by the attending medical officer, upon the patient's discharge from the department. The CPG and data collection form were designed to be incorporated into the patient's clinical record.

TELEform™, an automated forms processing (AFP) tool, is an alternative method of collecting data that allows treating clinicians to enter data on a particular clinical indicator (CI) in real time. The TELEform™ software allows users to create forms for collecting data that can be automatically read using a fax machine or scanner. Data fields may include hand-written or typed text, or multiple choice question “bubble” fields. Once data are entered, clerical staff can fax the AFP data to a computer that automatically collates information and can make it available for other applications. This system may reduce the time required for auditing and theoretically may reduce recording errors, although there has been minimal research into AFP's role in medical data collection. The list below summarizes medical usage, AFP technology advantages and disadvantages (Davidson et al., 1996, Puskar et al., 1996, Shiffman et al., 1997, Shaw et al., 1999, O'Rourke et al., 1999, Zehnder et al., 2004, Jirkovsky et al., 2003, Smyth et al., 1987, Hainsworth, 1995, Nies and Hain, 2000, Hardin et al., 2005):

1. **User**:
   - Basic data entry for research, including multi-site projects, epidemiological studies and mail out of surveys.
   - Distance mental health screening.
   - Generation of computer-based patient records.
   - Introduction of bar code readers for use in microbiology lab.
   - Hospital infection surveillance programs.

2. **Advantages**:
   - In house form design, can be tailored to the specific needs of the clinical setting, and easily revised.
   - Large amounts of data can be entered quickly, potentially saving time and cost.
   - Reduction in data collection error rates.
   - Ease of export to databases and statistical programs.
   - Facilitation of data collection from multiple sites and remote sites.
   - Minimal training required to attain proficiency.

3. **Disadvantages**:
   - High set-up and training costs.
   - Initial form design is difficult and time consuming.
   - TELEform™ cannot deal with unconventional question formats.
   - Technical issues such as software upgrades, hardware failure, security of information over a shared network and compatibility with statistical programs.
Published studies (Doherty et al., 2007a,b) on the effect of our CPG implementation relied on clinical record manual audit. There are a number of problems with manual auditing post discharge including time requirements, error rate, inter and intra-rater reliability, medical documentation quality and lost data. Most studies on implementing clinical guidelines rely on manual audit to determine CI compliance rates. If ACP is to be used by health service staff as part of their quality improvement programs then it is important to establish how ACP data correlates with manual audit data. It cannot be assumed that this new data collection system accurately reflects data collected by manual audit. To our knowledge, there has never been a direct comparison of compliance with CIs using both methods in the ED setting. The aim of this study, therefore, was to determine if ED clinical indicator data, collected by ACP, is similar to data collected by traditional manual audit.

Methods
All paediatric patients (<16 years) presenting to and discharged from Tamworth Rural Referral Hospital between August 1st and 31st 2006 inclusive, with one of five illnesses for which CPGs are used, were included in the study. The illnesses were gastroenteritis, asthma, head injury, bronchiolitis and croup. Tamworth Hospital is a 230 bed hospital and the major rural referral unit in New England area of New South Wales Australia. The ED is a mixed adult/paediatric department with an annual census of about 38,000 patients of which 10,000 are children. The admission rate is 18 percent. It has a specialist emergency physician on site 8-18 h per day. Junior medical officers, registrar and locums who rotate through the department provide additional medical staffing. Nurses are all dedicated to the ED but there are no allied health services. CIs were developed for each of these illnesses and a total of 16 CIs were created across the five conditions (Table 1).

The ED information system (EDS), an electronic database, was searched using ICD 9 diagnoses to identify paediatric patients. Selected patients’ notes were manually audited to monitor compliance with the CIs for their presentation. Two data extractors agreed processes and kappa analysis was performed to determine inter rater reliability. The manual data extractors also documented if the CPG had been incorporated into the medical record. After the collection period, ACP data from August 1st to 31st 2006, for the same 16 CIs, were accessed from the ACP database. Thus, two different data collection methods for the same patient population were compared. All data were subject to χ² testing (Epi info 3.3.2) and the kappa analysis was performed using SPSS version 14 for Windows. The CPG was a quality improvement exercise and had statewide ethics approval. Our study, comparing two different data collection methods, was performed under the auspices and within the time frame of that project. Hence, no individual institutional ethics approval was sought.

Results
Manual audit identified 127 presentations of the five illnesses for the month and ACP data identified 24 patients. The ACP data identified 18.9 percent of the total
presentations compared to manual audit. Of the 127 patients identified in the manual audit, 66 (52 percent) had the CPG completed and incorporated into the clinical record. The numbers of patients identified by each data collection method, for each illness, are shown in Table II.

The CI compliance rates, determined by manual data collection, were compared between those patients with the CPG completed and in the clinical record ($n = 66$) and those patients for whom it was not ($n = 61$). Compliance rates for each illness and combined are shown in Figure 1. In total, manual audit was completed for 347 CIs. When the CPG was completed and in the clinical record, overall compliance was 92.5 percent (175/187). When the CPG was not completed and within the medical record overall compliance was 51.3 percent (82/158). These values reached statistical significance ($\chi^2 = 73.33, p < 0.001$).

Figure 2 shows CI compliance rates, determined by manual data collection ($n = 347$), irrespective of CPG use, compared to compliance using AFP data ($n = 61$). Overall, compliance was 73.5 percent (256/347) using manual audit data and 96.6 percent (59/61) using AFP data. These values reached statistical significance ($\chi^2 = 8.34, p = 0.003$).

Fifteen records were chosen to test manual audit inter-rater variability. The calculated kappa coefficient for 34 variables was 0.77 indicating substantial agreement (Viera and Garrett, 2005).

<table>
<thead>
<tr>
<th>Illness</th>
<th>Manual audit</th>
<th>TELEform™ audit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croup</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Asthma</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Bronchiolitis</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Head injury</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td>24</td>
</tr>
</tbody>
</table>

Table II. Patients identified by data collection method and disease
Discussion

Few studies directly compare data collected by manual and AFP methods. One, Jorgensen and Karlsmose (1998), examined the processing of 401 questionnaires by four groups:

1. Manual data entry by a commercial data entry provider (single entry);
2. Manual data entry by a skilled secretary at the department performing double entry (entry on two separate occasions in SPSS data entry);
3. AFP using TELEform™ version 5.3 with the default form confidence level of 80 percent; and
4. AFP using TELEform™ version 5.3 with the maximum form confidence level of 99 percent.

The error rate for different form processing methods depended on the type of entry field. Data fields, such as dates, that required a cross in a box were much less error-prone than those requiring handwritten text. Overall, double-manual data processing was found to be the least error prone but AFP was comparable. Double-manual data processing was found to take 2.64 times longer and was 2.77 times more expensive than AFP (80 percent confidence). Another study (Smyth et al., 1997) found that AFP was slightly more accurate, far less time consuming and 95 percent cheaper than manual form processing, although in this instance a different software package, Formic™, was used.
Our data identified a number of important issues worthy of discussion. Less than one in five patients with conditions suited to CPGs had AFP data available despite 32 percent of patients having the CPG and corresponding AFP incorporated into their clinical records. This low rate of AFP data availability meant that if AFP data alone was used to determine compliance then information would have been absent for 81 percent of patients. For both asthma and bronchiolitis only one data set was reported on AFP for the month and yet there were 18 and 21 cases from manual audit, respectively.

Non-compliance with AFP may be multifactorial. There may be clinician disinterest in manually completing data collection, time pressures or lack of awareness about the forms and their purpose. The forms are readily formatted and may not allow clinicians to relay other issues related to guideline variance. Individual clinicians may also reject the guidelines as a clinical tool and with it the AFP. After the clinical consultation is over, the CPG and the AFP form part of the written clinical record along with the EDIS generated triage sheet and medical/nursing notes. The completed AFP sheets need to be unstapled from the notes and faxed by the clinical staff to a remote site computer where data are uploaded. Failure at any process stage may lead to data not entering the system.

AFP data overestimated our department’s performance by 17 percent, giving us a 90.5 percent compliance rate across the five conditions and 16 CIs compared to the 75.5 percent annual audit rate. This difference reached statistical significance. Coupled with the low rate of data available from the AFP audit, we cannot from this study, view AFP data as being sufficiently similar to manual audit data to reflect overall ED performance for these CI’s. Our AFP data were not representative of overall department performance and may reflect data from clinicians who are sufficiently motivated to not only comply with the guidelines but also to complete the data collection form, resulting in a biased subset.

The manual audit data revealed that in only 32 percent of cases was the CPG able to be located in the clinical record. Getting CPGs incorporated into the clinical record is a challenge not easily overcome in a busy ED with a high junior medical staff turnover, heavy reliance on locum staff, and the lack of electronic reminder systems. This 32 percent figure led to further departmental initiatives to maintain guideline awareness. The overall compliance from manual audit, across five conditions and 16 CIs is not too dissimilar to findings in some of our previous work (Doherty et al., 2007a,b). Following an evidence-based pediatric guideline implementation, we had a compliance rate of 78 percent for seven asthma CIs at 12 months post implementation. This audit period occurred ten months after that study. Similarly, for adult asthma we reported a 78 percent compliance rate across seven CIs for asthma. Data also reinforce the value of the CPG being available in a readily packaged form “at the bedside” for clinician use. When the CPG was incorporated into the clinical record, overall compliance was 95.5 percent, when it was not compliance fell to 81.3 percent.

Limitations
Our study has a number of limitations. First, it reports data from one hospital only. There was no comparing manual and AFP data for individual cases; hence there was no attempt to determine if AFP data accurately reflected the clinical record. There is no gold standard in auditing and the limitations of retrospective manual auditing were noted earlier. Further, the manual audit relied on identifying cases based on ICD 9 codes
entered into EDIS and may have missed patients. Nonetheless, manual audit is the most commonly used means of auditing and it is important to establish the relationship between new forms of audit to the traditionally used method. Inpatients were not included as it adds another layer of complexity. Once admitted, the GP part of the clinical record follows the patient. The ward clerical staff are responsible for fixing completed AFP data sets. Additionally, the patient’s clinical notes do not return to the ED but go to the medical records department making them less accessible for this study.

Conclusions and recommendations
Our study shows that data collected by AFP differs significantly from data collected by manual audit. The AFP data represented less than 20 percent of the target patient population and over-estimated departmental compliance with CIs by 15 percent. Theoretical advantages of AFP data collection will only be realized when systems are in place that facilitate much higher AFP data set completion rates.

References


**Appendix. Abbreviations**

**APF** – automated forms processing

**CAT** – Computed Axial Tomography

**CEC** – Clinical Excellence Commission

**CECP** – Children’s Emergency Care Project

**CI** – clinical indicator

**CPG** – clinical practice guidelines

**CXR** – chest X-ray

**ED** – emergency department

**EDIS** – emergency department information system

**ICD 9** – International Classification of Disease (version 9)

**SPSS** – Statistical Package for the Social Sciences

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Chapter 9: Discussion

This thesis has described a continuum of work beginning with the historical origins of evidence in health care and progressing through to trials of how evidence may be translated into clinical practice. The origins of evidence-based medicine and an understanding of its evolution were considered to be important steps in developing a better understanding of using evidence in practice. The colourful history was also used in early contacts with clinicians and in presentations during the course of the research as a means of stimulating interest in the subject.

Evidence for the management of acute asthma has been presented in Chapter 2 and evidence has also been provided regarding what strategies may be effective in translating this into clinical practice in Chapter 3. Three trials\(^1,2,3\) were presented which built upon this work. In these trials an “evidence-based implementation” strategy was used and all three trials produced changes in clinical practice, within rural emergency departments, that exceeded what could be expected from the literature\(^4,5\). Grol has argued that EBM should be complemented by an evidence-based implementation\(^6\) and has argued that many attempts to implement change has been based on the beliefs of the investigator. The evidence-based implementation strategies used in these studies were deliberately modelled on Sackett’s original definition of evidence-based medicine\(^7\), and is a novel concept in the science of implementation.

9.1 Translational Research

Lomas reasons that the ultimate aim of health research is not only to discover new knowledge that can be applied to patients, but also to then apply this knowledge to patients\(^8\). He argues that translational blocks occur because researchers and clinicians tend to operate in their own silos. Researchers are very good at communicating with researchers about future directions and what the next study should be, but researcher to clinician communication about implementing findings is uncommon and poorly organised\(^6\). Whilst in the ideal world there would be greater linkage between researchers and clinicians, the reality is that there isn’t. In order to effect knowledge translation, implementation strategies need to be as effective as possible to close evidence-practice gaps.
Translational research is becoming an increasingly important priority in North America and Europe with translational research centres being developed and funded. The Institute of Medicine’s Clinical Research Council defines two types of translational research and translational blocks can occur with both types. One type (T1) refers to the “transfer of new understanding of disease...into the development of new methods for diagnosis, therapy and prevention.” This translational research relates to basic biomedical research and the translation of knowledge about the basic sciences into human studies. Human studies lead to the development of new clinical knowledge. “The translation of results from clinical studies into everyday clinical practice” defines the second type of translational research (T2), and it is the translational block that occurs at this level that this thesis has been primarily concerned with.

9.2 Translational Blocks

The translational blocks T1 and T2 differ in many ways. T1 is immersed in the basic sciences, is laboratory based, empirical in its methods and generally quantitative research. T2 by comparison is more aligned with behavioural science, it is about changing the way populations of people do things within a complex health care setting. T2 is generally, though not always, qualitative in its methods.

Translational block is a real thing. In the United States recommended care is provided only 55% of the time for a range of acute and chronic conditions as well as for preventative care. Furthermore 20-25% of patients receive care that is not needed or harmful. In the Australian setting, and in particular related to asthma, the snapshot of asthma study showed significant deviations from recommended care. Spacer use was only 43% in children and <1% in adults. Ipratropium use was 38% in children with mild asthma and 65.5% in moderate asthma despite any evidence to support its use in such a setting. In adults it was used even more liberally with rates of 64% in mild asthma and 83% in moderate. Corticosteroids were used in only 71% of cases despite evidence for their effectiveness. Even children with severe exacerbations only received steroids 81.6% of the time.

A smaller, more recent Australian study also found low rates of compliance with clinical indicators used in the quantitative studies in this thesis. The assessment of severity was documented in only 18% of cases, corticosteroid prescribing occurred
71% of the time and provision of interim home asthma management plans occurred only 16% of the time\textsuperscript{14}.

In the three quantitative studies presented in this thesis\textsuperscript{1,2,3} compliance with recommended practice was less than optimal in the baseline data sets and ranged from 36% in rural district hospitals to 47% in paediatric patients in a rural referral hospital across 6-7 clinical indicators. All of the above mentioned studies demonstrate that even for a very common condition such as asthma, compliance with widely accepted practice occurred less than 50% of the time.

It warrants noting that the clinical indicators used to measure the effectiveness of asthma care in these studies are all surrogate measures. The prime aim of this thesis is to effect a change in clinical practice, not demonstrate the effectiveness of that practice. The literature review of asthma underpins the evidence for the practice recommendations.

Why was the baseline compliance in these three studies so relatively poor? Why was compliance with some similar indicators equally as poor in the 38 Emergency Departments that participated in the snapshot of asthma study? The evidence exists but the mere existence of evidence doesn’t mean it will be used. A number of reasons may exist that prevents the use of the evidence in clinical practice. These include:\textsuperscript{4,15}

1. the level and quality of evidence may not be persuasive enough to change practice
2. there may be barriers to applying the evidence in a complex setting such as an ED
3. the evidence may not be known to the clinician
4. the evidence may not be readily available when it is needed at the bedside.

Understanding the influence of these factors on the clinical decision making process is an important part of the barrier analysis that forms part of the planning process of an evidence-based implementation. Education and medical detailing may be useful strategies when the evidence is not known or the level of evidence is held to question (perhaps appropriately in some cases). Short reviews as presented in two different forums in chapter 5 are ways of providing concise evidence-based
references for clinicians. Clinical tools may require development, such as the A4 guideline used in these studies, or electronic support systems used in another, in order to bring the evidence to the “bedside.”

### 9.3 Barriers to Change

A more complex problem is an analysis of barriers to applying the evidence. Barriers to applying evidence have been defined as occurring at four levels.

1. The individual clinician
2. The health care team
3. The organisation providing care
4. The wider health care system

At a clinician level there may be a lack of knowledge or training, for instance about using a spirometer and interpreting the results or insufficient knowledge to instruct a child on spacer use and care. Similarly there may be a lack of awareness of the specific criteria to assess asthma severity as mild, moderate or severe and no clinical tools or reminders to make this easy for them. At a personal level, there may be an intrinsic resistance to change. The Everett Rogers diffusion of innovation theory has documented well the concept and characteristics of early and late adopters of new products and technologies. Others have observed similar characteristics in individual health professionals with regard to their adoption of new clinical practice or clinical guidelines.

Emergency Department doctors have been shown to have a high level of confidence that their practice with regard to pain management is appropriate despite evidence that there is room for significant improvement. Individual clinician confidence that their practice is optimal, even when it is not, is another barrier to changing that practice. Doust and del Mar have also highlighted that clinicians feel the need to do “something” and especially to meet patients’ expectations (whether real or perceived). Pierre Louis continued to provide venesection for his patients after demonstrating that early venesection led to an increased mortality in respiratory illnesses. This need to do something or meet “patient” expectations may partially explain things such as the excessive prescribing of antibiotics in afebrile patients that was found in the baseline data set. Further understanding of why practitioners
practice the way they do would provide more knowledge about how to target interventions, and provides a field for future qualitative research.

At the ED team level – specific practices have to compete with a whole host of other priorities. For instance, spirometry and teaching someone to use a spacer takes time, and if the department is busy or if there are sicker patients then it may be quicker, easier and arguably just as effective to give a nebuliser and come back to that patient when more pressing issues have been managed. Emergency Departments are also a potpourri of many patients at different stages and acuities of illness. Urgent conditions such as the assessment patients with acute coronary syndromes who may benefit from early reperfusion, multi-trauma victims and patients requiring resuscitation demand immediate attention. This is the reality of busy emergency departments. Less serious conditions such as the management of mild or moderate asthma or the use of clinical decision rules say for ankle injuries have to compete in this environment.

At a Health care system level EDs are busy places and have been described as being a “messy” environment. Qualitative research suggests ED nurses and doctors think that in general there is a lack of time and resources to provide the quality of care they would like, and that they are struggling to provide an adequate standard of care rather than striving for excellence.

At a departmental level there may be other barriers to providing the desired practice. For example there may not be spirometers available or there may not be a system in place for the provision of or reuse of spacing devices. Similarly there may be no systems in place that provide clinicians with ready access to the evidence they need.

In the same way that there are barriers there are also facilitators that make it easier to practice better. These may include opinion leaders, good leadership, education regarding practice and evidence and engagement of staff at all levels into change programs. Minimising barriers and maximising facilitators becomes an important part of an EBI. Understanding the role and influence of specific barriers and facilitators in the ED is an important scope for future research.

The great challenge for T2 research is that there is still much that is unknown. Strategies for implementing guidelines and other practices have been studied, but largely the influence of such strategies is modest. It is still not known if some
strategies are more effective in different settings, for instance are opinion leaders more effective in a medical hierarchy as opposed to a group practice with partners of equal standing.

Within a hospital system it is not known if strategies would have the same effect in an acute ward as they would in a chronic care ward. Within a hospital all wards are unique and within a health care system, wards with a similar function can also differ quite significantly. For these studies Emergency Departments were used, but EDs have different case-mixes, patient census and staffing profiles depending on their location\(^\text{23}\) (metropolitan, regional, rural and remote). Furthermore, even EDs of similar size in similar locations are made up of unique individual staff members who are the basis of patient care. The characteristics of these people as individuals, as well as the dynamics of the groups they are members of, and the dynamics and teamwork of the ED as a whole are all likely to be different. It is likely too that the processes and procedures in the departments will be different.

### 9.4 Evidence-Based Implementation

This concept of each ward or medical department being different (even wards that serve the same function such as EDs) is one of the three key components of an evidence-based implementation. If we recall Sackett’s definition of EBM\(^\text{24}\) it can be summarised as the best available evidence, judiciously applied to an individual patient. Whilst there may be shortfalls in the evidence of how best to change practice, or implement change, there is nonetheless a substantial evidence base. It is this evidence base that was consulted in order to derive the implementation strategies used in this thesis, strategies that were adapted and individualised to individual EDs as needed.

The third component of EBM and EBI is judiciousness. In Sackett’s definition, the doctor is the applier of judiciousness. They require knowledge of the evidence for the management of a particular disease and also knowledge of the patient. The doctor, as a broker, facilitates the bringing of the two knowledge bases together, to decide on the management options. Hence the same evidence could be applied in different ways to different patients. In an EBI strategy a different type of broker would replace the role of the doctor. This broker would have a thorough knowledge of the evidence for changing practice and the evidence that supports that practice.
They would also have a thorough knowledge of the ward or department where change was being targeted.

Meta-analysis has determined that a favourable change in clinical practice of around 10% can be expected when a successful an implementation strategy is put into place\textsuperscript{4,5}. The quantitative papers in this study demonstrated changes in the range of 26% to 41% that were sustained at 12 month follow-up. These significant changes in clinical practice suggest that an EBI strategy designed specifically for an individual department and tailored to suit that unique department, can produce changes of greater magnitude than previously accepted measures of successful implementation. If we consider the role of the broker, then the author as the broker in all the intervention hospitals had a greater knowledge of the rural referral hospital than of the rural district hospitals. One could speculate that this may be one reason why the changes in practice were more marked at the rural referral hospital than in the district hospitals.

9.5 The Ethical Argument for Translational Research

It could be argued that translation research (T2) has the capacity to save more lives than T1 but only 1.5% of the current medical research budget is spent on this aspect of health care research\textsuperscript{25}. One could argue that this means we need greater awareness of the difference between developing treatments and having them used in practice. It has been argued that we are in the phase of diminishing returns with respect to health care\textsuperscript{26}. Advances in health over the last 50-100 years has greatly increased longevity in the West. In the US average life expectancy for women has increased from 46.3 years in 1900 to 79.9 years in 2000\textsuperscript{27}. For the same time period average life expectancy for men has increased from 48.3 to 74.2 years. Benefits in mortality and morbidity are now only occurring in small increments and at great cost as newer, better diagnostics and newer, more expensive treatments become available\textsuperscript{26}. In keeping with technological advancement in industry the latest gains in healthcare have been the hardest. In addition the newer technologies and treatments are expensive and largely only affordable by the wealthy, who have the least need\textsuperscript{26}. It has been argued that greater health gains could be made by better application of what we already know, to more people, at a fraction of the cost\textsuperscript{26}. It is this viewpoint, based not only on moral but also economic foundations, that underpins the importance of translational research, not only from a global perspective but also within more affluent countries.
9.6 Data Collection

The quantitative research in this thesis could be described as quality improvement research with the significant difference being the scientific rigour surrounding the trials and methods of data collection. The development of an automated data collection method during the conduct of the study for a range of paediatric emergency conditions, including asthma, presented an opportunity to study different data collection methods. The Children’s Emergency Care Project was a state-wide quality improvement project that embraced the new automated data collection method during the course of the project. As the paper presented in Chapter 8 demonstrates, the method of data collection is important and can significantly affect results in a before and after trial. This reinforces the judiciousness of using research methodology if we want to learn more about the process of implementation whilst attempting to implement changes in clinical practice.

Limitations

The individual papers discuss the limitations in each study but it is worth mentioning the limitations of these papers with respect to the implementation literature.

We don’t know if this approach will work in other settings. Will an EBI strategy work in other ward types be they other acute wards such as intensive care or even chronic care wards such as rehabilitation units. Similarly we don’t know if such strategies would easily be transferred across geography into major metropolitan hospitals which by their nature are even larger and more complex organisations.

A barriers analysis was performed but this is specific not only to this department but also to this condition. Hence the barrier analysis is uniquely individual. Other hospitals will have different barriers which will influence how the evidence base for implementation is adapted for the local needs.

An EBI is by its nature a multi-faceted intervention and from these studies which utilised reminders, audit and feedback, education, opinion leaders and medical detailing we don’t know which if any of these strategies were the more effective. Qualitative research looking at which components of this EBI were the most
effective would add further understanding to what drives change and also add to the implementation knowledge base.

The concept of the author and others involved with the implementation of the asthma guidelines becoming brokers arose during the course of this study. At the commencement of the trials the concept of brokering was not considered but as I developed more knowledge about the science of implementation the role of brokering became better understood. It is not possible to know what role the implementers had as brokers. The implementation teams all included some members who were considered opinion leaders, as evidence supported this. However it became apparent during the studies that some team members were clearly acting as brokers with knowledge of the clinical evidence, knowledge of how to effect change and implement guidelines and also knowledge of the department we were attempting to make changes in. In the same way that this study doesn’t answer which components of the multi-faceted implementation were most effective, it also doesn’t answer what role brokerage had in the implementations.

**Conclusion**

The translation of findings from high quality clinical trials into clinical practice remains a great challenge. This thesis confirmed that even for one of the most common conditions presenting to EDs in Australia, acute asthma, there was only 38-47% compliance with indicators of standard clinical practice. This fact underpins the importance of knowledge translation, and the need to identify and understand which strategies work best with respect to the science of implementation and translational research.

Key (measurable) clinical indicators for acute asthma were developed and the evidence base for implementing change was used to develop an evidence-based implementation strategy. This strategy was successfully trialled in rural emergency departments for patients presenting with acute asthma. The positive change in clinical practice that resulted was two to four times more than that accepted as evidence of successful knowledge translation.

There is evidence to support some strategies used in knowledge translation but the evidence base for knowledge translation remains incomplete and in need of further study. The success of the qualitative and quantitative measures in the published studies, demonstrate that not only is the development of an evidence-based
implementation strategy possible, but that it can be used to successfully translate evidence into clinical practice.

The basis for the success of the studies incorporated into this thesis is the development of a scientific approach to translational research and the concept of an evidenced based implementation as a mechanism for achieving best clinical practice. In these studies high compliance with best clinical practice was achieved in the management of acute asthma in multiple rural emergency departments in northern New South Wales. Further research applying this methodology to other diseases and other health care settings is indicated to see if using an EBI strategy is a common pathway for achieving best clinical practice for patients in need of health care.
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Appendices
Appendix 1: History, pathophysiology, clinical presentation and role of hyperbaric oxygen in acute carbon monoxide poisoning

Abstract

Acute carbon monoxide poisoning remains a major cause of morbidity and mortality, both in the medical and industrial setting. This review examines the current understanding of the pathophysiology of carbon monoxide poisoning and the historical evolution of these concepts. The clinical presentation is discussed in relation to the various organ systems. Finally, the history and role of hyperbaric oxygen is also discussed. Hyperbaric oxygen therapy is an established, although not universally proven, treatment option.

Keywords: carbon monoxide poisoning, hyperbaric oxygen

Introduction

Carbon monoxide is a colorless, odorless gas present in idling, stopped engines and paint strippers. It is the leading cause of fuel-related deaths in the United States of America (USA) with approximately 1000 accidental deaths, and up to 4000 intentional deaths per year. Reliable national data for Australian poisonings is unavailable. A study in the Hunter region of New South Wales (NSW) found an incidence of approximately 10 deaths by carbon monoxide per year over a 5-year period for a greater population of 800 000. These figures do not include poisonings that present to other hospitals in their region and are not referred on, or those that are referred directly to hyperbaric centres. While these figures encompass accidental deaths, such as in house fires, most deaths attributable to house fires are due to carbon monoxide.

Carbon monoxide is produced from the incomplete combustion of hydrocarbons. Exogenously, it is produced during the metabolism of heme-containing iron in normal red blood cells, with levels in heavy smokers reaching as high as 10–15%. Exogenously, which exist in paint strippers, is readily absorbed via the skin and lungs. Hepatic metabolism of methemoglobin reduces the formation of carbon monoxide.
Carbon monoxide has a high affinity for haemoglobin and binds to it forming carboxyhaemoglobin. Carbon monoxide also binds to cytochrome c, the terminal enzyme of the cellular respiratory chain, which is the site where oxygen is consumed by the cell. It also binds to myoglobin. Brain lipid peroxidation is also believed to play a role in the neurological manifestations of carbon monoxide toxicity.

Symptoms of toxicity are not specific and correct treatment involves supportive care and aggressive oxygen therapy. The role of hyperbaric oxygen therapy remains controversial, although established.

The history of carbon monoxide

Numerous studies since 1857 have gradually unravelled more information about carbon monoxide toxicity. In 1857, Bernard demonstrated that carbon monoxide produced hypoxia via its combination with haemoglobin. In 1895, Halstead demonstrated that mice exposed to one atmosphere of carbon monoxide (resulting in 100% carboxyhaemoglobin levels) and two atmospheres of oxygen remained alive although easily exhausted. He concluded from this that carbon monoxide produced its poisoning purely by binding to haemoglobin, the hypoxic theory of toxicity, and that oxygen at two atmospheres provided sufficient dissolved oxygen in plasma to sustain cellular respiration. It is worth realising that the arterial–venous oxygen difference is approximately 5 mL per 100 mL of blood per minute and that the total amount of oxygen is blood is given by the formula:

\[
\text{oxygen per 100 mL of blood} = (1.34 \times Hb \times O_2 sat) + (0.025 \times P_O)
\]

Where \(1.34\) is a constant, \(Hb\) is haemoglobin concentration (g/L), \(O_2 sat\) is oxygen saturation (%) and \(P_O\) is partial pressure of oxygen (mmHg).

At two atmospheres the \(P_O\) is in excess of 400 mmHg, and 1400 × 0.025 = 4.2 mL is enough dissolved oxygen in plasma to sustain cellular respiration, regardless of the presence of haemoglobin, functioning or otherwise.

In 1923, Seidlay et al. demonstrated that carbon monoxide had an affinity for haemoglobin which was 210 times greater than the affinity of oxygen for haemoglobin. Hall et al. in 1931 showed that the affinity of carbon monoxide for cytochrome c with respect to oxygen was 1:5.2. Goldbaum et al. in 1976 rendered Halstead’s hypoxia theory of toxicity untenable with his experiment on exsanguinated dogs. He transfused partially exsanguinated dogs with donor blood containing 80% carboxyhaemoglobin providing average carboxyhaemoglobin levels of 80%. The transfused dogs showed no ill effects, whereas dogs with similar levels after exposure to carbon monoxide had died. This demonstrated that toxicity at a cellular level needed to occur.

Current understanding is that carbon monoxide produces toxicity via three main mechanisms: hypoxia, cellular toxicity and free radical-mediated cellular injury. Carbon monoxide’s affinity for the haemoglobin molecule effectively negates the role of haemoglobin in the principal means of oxygen transport in severe toxicity. This, in turn, leads to cellular hypoxia. In addition to binding to haemoglobin, bound carbon monoxide also shifts the oxyhaemoglobin curve to the left, making any bound oxygen less able to dissociate and, hence, less able to be used by tissues.

Cellular toxicity relates to carbon monoxide’s ability to bind to other enzymes and proteins. In particular, binding to cytochrome a damages the ability of cells to consume oxygen in the mitochondria. Goldbaum et al.’s experiments showed that carbon monoxide must be dissolved in plasma, albeit transiently, if binding to cytochrome a is to occur. If enough oxygen is present at the cellular level, it will displace carbon monoxide from the cytochrome. Unlike carboxyhaemoglobin, the half-life of the carboxyhaemoglobin complex is not known. Cellular toxicity may also result from carbon monoxide binding to myoglobin with an affinity three-fold greater than for skeletal muscle.

In the rat, it has been demonstrated that lipid peroxidation (degradation of unsaturated fatty acids) can occur secondary to the formation of oxygen free radicals following carbon monoxide exposure, and that partially reduced oxygen may contribute to carbon monoxide-mediated damage to neurons during re-oxygenation.

Clinical presentation

The symptoms of carbon monoxide poisoning are often vague although in the acute setting the diagnosis is normally given away by the history. Symptoms due to chronic exposure include headache, dizziness, weakness and nausea. Acutely, the signs and symptoms correlate well to the carboxyhaemoglobin
level at the scene. Once the patient has been removed from the scene or has had supplemental oxygen the correlation is poor. Hence, if carboxyhaemoglobin levels are measured, the specimen needs to be a field sample. With the advent of catalytic converters in automobiles, carbon monoxide emission rates have dropped almost 50-fold. Deliberate exposure to these lower levels, for prolonged periods of time, may still result in fatal poisoning despite relatively low carboxyhaemoglobin levels. In these instances it is more likely that binding of carbon monoxide to cytochrome a, and free radical-mediated damage are the main pathophysiologic mechanisms of damage.

The signs and symptoms at presentation are dependent upon the following factors: (i) concentration of carbon monoxide exposed to; (ii) duration of exposure; (iii) minute ventilation; (iv) metabolic rate; (v) haemoglobin concentration; (vi) oxygen therapy; and (vii) time elapsed since exposure. Factors 1–5 influence the carboxyhaemoglobin level at the scene and factors 6 and 7 influence the level in the emergency department.

It is useful to consider the clinical manifestations of carbon monoxide poisoning as neuropsychiatric, cardiorespiratory and other.

**Neuropsychiatric presentation**

Disturbance of neuropsychiatric functioning may occur as a presenting feature and may persist, or it may develop as a delayed sequelae. The major symptoms are headache, dizziness and weakness. With increasing toxicity, confusion, decreasing level of consciousness, fits and coma can occur. Almost every known neurological syndrome has been described in the medical literature following carbon monoxide poisoning. The most important pathologic changes in carbon monoxide poisoning occur in the white matter and include demyelination, petechiae, oedema and necrosis. In 1983, Shutler performed a series of autopsies on carbon monoxide-poisoned people and noted characteristic brain lesions in three phases. In people who died immediately after exposure, post-mortem revealed petechial haemorrhage throughout the brain with no oedema. In people who died within hours to days of exposure, he noted periventricular necrosis of the globus pallidus. In people who died within days to weeks of exposure, there was no oedema but widespread demyelination and degenerative changes. In 1986, Misra demonstrated changes on computed tomography (CT) associated with white matter and the globus pallidus. Low-density lesions associated with the globus pallidus, as demonstrated by CT are associated with a high incidence of delayed sequelae. This area has a relatively low oxygen requirement and the changes are likely to be the result of an hypoxic-ischaemic insult.

Long-term neuropsychiatric sequelae are well documented. Smith and Branson demonstrated that gross neuropsychological damage occurs in approximately 11% of survivors. Memory impairment occurs in 50% and emotional personality changes in 30%. Such changes include increased irritability, violence, psychosis, impulsiveness and decreased intellect. The resolution of such changes may take up to 2 years.

Delayed sequelae usually follow coma-inducing exposure. After a relatively symptom-free period of from 1 to 240 days, the patient undergoes rapid neurological decline. The commonest symptoms are decreasing cognition, incontinence and gait disturbance. Diffuse demyelination is associated with these sequelae. Resolution may occur in 50–75% within 1 year.

**Cardiorespiratory presentation**

The brain and the heart have the highest metabolic requirements, so it is not surprising that these two organs bear the brunt of carbon monoxide toxicity. The affinity of carbon monoxide for cardiac myoglobin is similar to that for haemoglobin. Carbon monoxide also contributes to cardiovascular toxicity, as does the requirement for an increased cardiac output to compensate for cellular hypoxia. Dyssrhythmias and ischaemia (especially subendocardial) are the major manifestations of cardiac disease. The threshold for ventricular fibrillation is lowered by carbon monoxide and the electrocardiogram will often show ST segment and T wave changes of ischaemia. Pulmonary oedema due to cardiac failure, hypoxia or associated with other inhaled toxins, and aspiration secondary to depression of the central nervous system are other common manifestations.

**Other organ systems**

Visual changes are common and retinal haemorrhages are often seen. Cherry red skin is seldom seen, most patients appearing cyanotic. Rhabdomyolysis may occur due to prolonged hypoxia or pressure. Failure of any organ system, disseminated intravascular coagulation and thrombotic thrombocytopenic purpura may all occur.
The fetus is exquisitely susceptible to the effects of carbon monoxide, which is also teratogenic. Fetal susceptibility is due to the following:

1. The fetal fetal O2 dissociation curve is left shifted.
2. The fetal fetal 

3. Fetal carboxyhemoglobin levels, although slower to equilibrate, by up to 12 h, are 16–17% higher than adult levels.
4. Fetal carbon monoxide elimination is slower, resulting in a half-life 3.5-fold greater than for adults.

Up to 89% of children born to exposed mothers have neurological sequelae. Up to five times the duration of hyperbaric oxygen therapy has been recommended for pregnant patients. There is no correlation between maternal carboxyhemoglobin level and fetal outcome.

Investigations and diagnosis

A high level of suspicion is necessary as there are no pathognomonic signs or symptoms. Consider screening for other drugs if the poisoning results from a suicide attempt. In a recent study, 44% of carbon monoxide-poisoned patients who had attempted suicide, had congested alcohol or other drugs.

Carboxyhemoglobin levels may assist if the diagnosis is not known. In known exposures, if the carboxyhemoglobin level is not taken immediately upon removal from the scene, then the level will be influenced by the elapsed time since removal from the scene and the duration and concentration of oxygen therapy. These factors make interpretation of the level difficult. Furthermore, with newer model vehicles, significant toxicity may occur with relatively low levels. Given that high carbon monoxide levels are unlikely to be present without symptoms, the value of carboxyhemoglobin levels remains questionable.

Attenuated blood gas analysis will reveal a normal PaO2, (because most machines measure dissolved oxygen and carboxyhemoglobin; PaO2, from this) and lactic acidosis. Because most blood gas analyzers calculate the oxygen saturation from the dissolved concentration of oxygen in plasma, which is unchanged in the presence of carbon monoxide, then a normal oxygen saturation is also recorded. If direct oximetry is performed using a spectrophotometer, the oxygen saturation is much lower and this saturation gap is characteristic of carbon monoxide poisoning. Transcutaneous pulse oximetry does not reveal the saturation gap because it too is falsely high, although for a different reason. Abnormal forms of hemoglobin, including carboxyhemoglobin, are not sufficiently discerned by the sensor and, hence, a false high reading is also given.

In addition, an electrocardiograph may reveal ischemic changes. Cardiac troponin, creatine kinase (muscle) and uric acid analysis for myoglobin may demonstrate carbon monoxide-mediated damage to striated muscle. A chest X-ray may demonstrate pulmonary edema, aspiration or other pulmonary complications.

A cerebral CT may demonstrate the neurological changes discussed. A thorough neurological examination andminor mental state examination (e.g., Folstein's) should be performed if the patient is conscious. Hyperbaric centers have formal neuropsychiatric tests which are lengthy; however, there is no standardized test. A number of studies have shown improvement in neuropsychological tests in patients treated with hyperbaric oxygen but factors such as repetition, sleep, withdrawal from other drugs and resolving depression have not been factored in.

Treatment

The controversial area in the management of carbon monoxide poisoning is the role of hyperbaric oxygen therapy. Hyperbaric oxygen was first used in carbon monoxide poisoning in 1969 and in 1942, poisoned animals were first treated. In 1946, human volunteers were first treated and Smith, in 1962, was the first to treat carbon monoxide-poisoned patients.

In 1950, Piano et al. demonstrated the half-life of carboxyhemoglobin. The currently accepted figures for the half-life of carboxyhemoglobin are 5 min in room air, 20% in 10% oxygen; 25 min with 100% oxygen at three atmospheres and 15 h for fetal carboxyhemoglobin. Nevertheless, in 1978, was the first to treat delayed sequelae with hyperbaric oxygen. Hyperbaric oxygen can provide enough oxygen dissolved in plasma to meet the requirements of the tissues. It reduces the half-life of carboxyhemoglobin and displaces carbon monoxide from the cytochrome.

Tribble and Perrotta found, after reviewing all published literature on hyperbaric oxygen treatment, that there is some support for its use, but that no randomized, controlled, blinded trial had ever been done. Until recently, all previously published studies had many faults due to poor randomization, no
blinding, poor follow up, low numbers of subjects and lack of standardized treatment for both hyperbaric and normobaric oxygen.

Until 1994 only five prospective trials of more than 30 patients comparing hyperbaric to normobaric oxygen had been published.\textsuperscript{22-27} Raphael et al.\textsuperscript{24} in one arm of their study, found no difference in the rate of delayed neurological sequelae in 170 patients with mild carbon monoxide poisoning receiving normobaric oxygen, compared with 172 patients receiving hyperbaric oxygen. The rates of sequelae were 34% and 52%, respectively, at 1-month follow up. The normobaric groups received 6 h of 100% oxygen and the hyperbaric group received 1 h at two atmospheres plus 4 h of normobaric oxygen. This study had a short follow-up time (1 month), did not include neuropsychiatric testing and did not include severely poisoned patients in this arm.

Nyer et al.\textsuperscript{28} in an unblinded, uncontrolled and randomized study, followed 273 patients with carbon monoxide poisoning. One group (131 patients) had carboxyhaemoglobin levels of greater than 20%, abnormal neuropsychiatric tests, abnormal neurological examination or a history of loss of consciousness. This group received hyperbaric oxygen at 2.8 atmospheres for an unspecified time and these were no sequelae at follow up of 0-12 months. The other group (82 patients) had normal or borderline neuropsychiatric and carboxyhaemoglobin levels of <20%. They received normobaric oxygen for 1-4 h with less than 5% receiving treatment for greater than 1 h. Two of this group (12%) developed sequelae at follow up, however, two of these 10 received no oxygen at all and those had no sequelae for group 1.

Corman et al.\textsuperscript{29} compared normobaric oxygen to single and multiple hyperbaric oxygen treatment in 100 consecutive patients. Only eight patients received normobaric oxygen because treating physicians perceived it to be associated with increased sequelae during the first year of the 3-year study. The normobaric oxygen regimen was not stated in the study. Hyperbaric oxygen was administered at 2.8 atmospheres for 60 min. They found no difference in the incidence of delayed neurological sequelae between normobaric and single hyperbaric oxygen therapy, but a significant decrease in sequelae in those receiving multiple hyperbaric treatments. Loss of higher functions and depression were the most common sequelae, and 31% of enrolled patients had attempted suicide. Twenty-four per cent of patients were lost to follow up which took place at 1 month. These results conflict with the other arm of the study by Raphael et al.\textsuperscript{25} in which one session of hyperbaric oxygen was compared with two. Patients in the arm had initial improvement of coma, and one week and six were received a further 4 h of normobaric oxygen. This study found that two sessions conveyed no benefit over one session at 3 month follow up.

Thorup et al.\textsuperscript{30} performed a randomized, prospective trial on 65 patients with no history of loss of consciousness or cardiac mortality after carbon monoxide poisoning. Thirty-two patients received normobaric oxygen via a non-rebreathing mask until symptoms resolved (average treatment time 42 h). Thirty-three patients received hyperbaric oxygen at 2.8 atmospheres for 90 min. Followed by two atmospheres for 90 min. Thirty patients in each group attended 1-month follow up and the rate of delayed neurological sequelae was 23% in the normobaric group and 0% in the hyperbaric group. Problems with this trial, as elucidated by Olsen and Seger, included no baseline neuropsychological testing, post-treatment testing taking place in a variety of environments (including the patient’s home) and an increased age and incidence of cardiorespiratory disease in the normobaric oxygen group

Mathews et al.\textsuperscript{31} in an unblinded trial compared hyperbaric oxygen at 2.8 atmospheres for 90 min to 2 h of normobaric oxygen in 575 non-comatose patients. All patients had carboxyhaemoglobin levels greater than 16%. They found a significantly lower rate of persistent neurological sequelae at 3-month follow up in the hyperbaric group and fewer (although not significant) rates of persistent neurological sequelae at 1.5 and 12 month follow up.

A recent Australian trial\textsuperscript{32} of 191 patients is the only prospective, blinded, randomized trial comparing hyperbaric to normobaric oxygen therapy in carbon monoxide-poisoned patients in which severely poisoned patients were included. It also included a sham treatment for the normobaric group. This study found that 3 days of hyperbaric oxygen (2.8 atmospheres for 90 min each day) offered no benefit to outcome over 3 days of normobaric oxygen treatment (90 min at 300%)

Similarly, the intrinsically randomized, controlled, American study\textsuperscript{33} using sham treatments and involving 51 patients show no difference in the incidence of persistent neurological sequelae in those treated with hyperbaric or normobaric oxygen. There may be a trend in the incidence of delayed neurological sequelae in one of the blinded treatment groups. In this
study, 70 eligible patients have not been referred into the study and the normobaric oxygen regimen has not been specified.

Critiques of the Australian study include a low follow-up rate (46%), an early follow-up of 1 month, a high incidence of depressed patients, and no baseline neuropsychiatric assessment other than the Fleson mini-mental state examination. In addition, their regimen for normobaric oxygen may have been more effective than that in other studies. Normobaric oxygen in this group consisted of 100% oxygen and lasted for 3 days. This extended to 6 days if patients were clinically abnormal or had had neuropsychological testing at 3 days. In four of the aforementioned studies, 11,21,25,26 normobaric oxygen therapy was not defined or had ceased within 6 h of hospitalization.

While the debate about hyperbaric oxygen will continue, the mainstay of treatment will remain. These include immediate removal from the source, application of 100% oxygen as soon as possible and supportive care, including appropriate airway management. Associated co-intoxications and injuries need to be sought and managed appropriately.

Conclusion

The history of carbon monoxide poisoning has evolved over a century or more and provides a colourful chapter in toxicological research. The pathophysiology is still being unravelled, but a combination of hypoxic injury, cellular toxicity and free radical neuronal injury are the current suspects in carbon monoxide-mediated injury. Many studies have failed to show any scientific benefit in the use of hyperbaric oxygen although none of these studies has been without limitations.

References


Hyperbaric oxygen (HBO) therapy is a safe, logical and readily available technique for acute carbon monoxide (CO) poisoning in major Australian cities. However, few other areas in medicine have created such heated debate between those who think there is a role to play and those who do not. Delowering, in this edition of Emergency Medicine, provides a clear and concise review of CO poisoning and has documented the physiological rationale for the use of HBO. The debate about the use of HBO centres on the method of conflicting and conflicting research. Currently, it is impossible to analyse accurately the various studies and to arrive at an evidence-based decision. Review articles are valuable, and with the acknowledgement that in their opinion, the weight of evidence either supports the use of HBO or does not support it. This will always happen when two groups of limited research are compared.

The current evidence is not clear enough to give a definitive answer. This is not to criticise the researchers, who should be congratulated on attempting to shed light on this difficult area of medicine. Research into CO poisoning is notoriously problematic. It is difficult to blind placebo groups into a hyperbaric chamber and compare them to controls. Skewed results can also be thrown by administering breathing air and out of the chamber without changing the exposure. It is doubtful if this truly blunts the patient to the nature of the treatment. Neurological tests that are used to diagnose the delayed sequelae are impossible to perform in the acutely poisoned patient and, therefore, the results are not reliable. Follow-up of these publications also poses questions.

Traditionally, the consensus opinion has been that HBO should be offered to patients with severe CO poisoning and those with good research has proved HBO beneficial. However, recently in Australia (and in New Zealand) there has been a paradigm shift and it now appears that many clinicians have decided that they will not offer treatment until HBO has been proven effective. This has resulted in a marked reduction in referrals to hyperbaric medicine units of patients with acute CO poisoning. Others have decided that they will only consider certain clinical situations and some have decided that they will offer HBO to selected patients only if they are not evaluating the effectiveness of HBO.

What is known about CO poisoning is that there is good evidence that HBO works at a cellular level to reverse the pathological changes induced by CO.
Hyperbaric oxygen therapy reduces the half-life of both carboxyhaemoglobin and the CO-sytochrome enzyme complex. There are minimal complications from hyperbaric exposure. With the advent of critical-care retrieval teams, transport of ventilated patients is now extremely safe. What is unclear is whether or not HBO makes any clinical difference, who is at risk of delayed neuropsychiatric sequelae and how to grade the severity of poisoning. Until there is evidence to the contrary, it is logical to hasten the removal of a toxin from the brain and the myocardium where it is causing damage. There are no double-blind, controlled studies of the use of haemodialysis for severe methanol and ethylene glycol poisoning but haemodialysis is still performed to remove the toxins as rapidly as possible. Haemodialysis will continue to be offered to these patients until there is good evidence that it does not help. It is not clear why a different yardstick should be applied to CO poisoning.

Much has been made of Schenkessel et al.’s paper and the criticisms have been well documented. In my opinion, it does not provide adequate evidence that HBO should be withheld from patients with CO poisoning who have appropriate indications. If clinicians decide not to refer their patients, based on Schenkessel et al.’s paper, then they should ensure their patients are admitted for 72 h of high-flow oxygen, as was given to the control group in the study. The practice of dismissing HBO on the basis of Schenkessel et al.’s study, then creating acute severe CO poisonings with 4 h of 100% oxygen before discharging them, is obviously not appropriate.

Clinicians should also bear in mind that treatment with HBO will often prevent the need for hospital admission. This saves Health Department’s money and reduces the pressure on hospitals already compromised by access block. All hyperbaric medicine units in Australia and New Zealand, except the Alfred Hospital unit in Melbourne, still encourage referral, and the Undersea and Hyperbaric Medical Society continues to recognize acute severe CO toxicity as an indication for HBO. It is hoped that currently ongoing large trials in the United States will soon allow a more evidence-based decision to be made.

References
Carbon monoxide poisoning

Dr. Bouchier is to be congratulated on the review of the anaerobic mode of carbon monoxide (CO) poisoning in his paper "Letters to the Editor," pathology, clinical presentation, and role of hyperbaric oxygen in acute carbon monoxide poisoning. Here, I would like to present alternative views and data to support the conclusions regarding the role of hyperbaric oxygen therapy in the management of CO poisoning.

CO pathophysiology

Recent pathological injury has been detected in CT and post-mortem studies of CO victims. To date, there is no consensus on the mechanisms of CO poisoning. It is now known that hyperbaric oxygen therapy (HBOT) can reverse neurological damage caused by CO poisoning. At least two mechanisms are postulated: restoration of oxygen to the brain and reversal of excitatory amino acid toxicity. HBOT has been shown to improve neurological function in patients with severe CO poisoning.

Clinical outcomes

Although recent studies have failed to show any benefit of HBOT in the treatment of CO poisoning, some studies have shown improvements in neurological function in patients treated with HBOT. This is consistent with previous studies showing improvements in neurobehavioral function and reduced mortality in patients treated with HBOT.

Acute reversibility

This is due to the cellular effects of CO, including lipid peroxidation, as outlined in Bouchier's paper. This is corrected by rescue from the CO environment, administration of 100% oxygen or hyperbaric oxygen (HBO). Hyperbaric oxygen treatment considerably reduces the neurological deficits of CO compared with oxygen at 0.6 atmospheres absolute (ATA).

Standard HBO treatment for CO poisoning in Australia is 28 ATA for 2 hours. The pressure required is considered safe with no reported complications. However, there is evidence that a greater benefit can be achieved with higher pressures. For example, a study by Bouchier et al. showed that treatment with 30 ATA for 2 hours was associated with a significantly lower mortality rate compared to treatment with 24 ATA.

Further analysis of our data has demonstrated CO elimination half-life of 27.22 min (95% CI 25.65-28.79 min, range 18.39-35.59 min) in HBO2/4 ATA (5 patients), compared with 46.59 min (95% CI 38.65-54.53 min, range 32.79-60.14 min) for 100% oxygen 2.0 ATA (6 patients). Our results are consistent with those described by Bouchier et al. in a similar study.

We also found that if adverse reactions were measured, elimination half-life is prolonged within treatment groups, HBO and HBO2. Our results are consistent with those described by Bouchier et al. in a similar study.

Persistent early morbidity — Irreversible neurological injury

All at times present neurological injury between irreversible, post-treatment due to the combination of brain damage, hypothalamic, and cortical effects associated with the underlying, potentially reversible toxicity. Studies of persistent early morbidity (PEM) as an outcome measure have demonstrated the worst prognosis for patients with PEM and follow-up very considerably among trials.

We present a summary of the outcome data for PEM from five major prospective trials [refs]...
Delayed neurological syndrome

Delayed neurological syndrome (DNS) occurs after there has been an apparent recovery during acute treatment. As outlined in Dheery’s paper, the syndrome may follow coma-inducing exposure, and may be worse in the elderly. Available evidence suggests a treatment advantage for HBO in preventing this syndrome in seven prospective trials summarized below:

- Myers et al. (1985) P, non-R, C, U (42 patients – follow up: 6 months)11
  100% oxygen DNS = 18 (42.9%), HBO DNS = 6 (14.3%), 100% oxygen DNS = 0/42, HBO DNS = 4/42, P < 0.001
  HBO favouring 100% oxygen.

  100% oxygen DNS = 2/26 (7.7%), HBO DNS = 2/26 (7.7%), 100% oxygen DNS = 0/26, HBO DNS = 0/26, P = 0.82
  HBO and 100% oxygen favouring HBO.

  100% oxygen DNS = 10/35 (28.6%), HBO DNS = 4/35 (11.4%), 100% oxygen DNS = 0/35, HBO DNS = 0/35, P = 0.004
  HBO favouring HBO.

- Smart et al. (1995) P, C, D (66 patients – follow up: 3 months)14
  100% oxygen DNS = 32 (48.5%), HBO DNS = 24 (36.4%), P = 0.03
  HBO favouring HBO.

Our study of 66 patients allocated to HBO and NBO by a prospective protocol was reported in abstract in 1995. We measured elimination of expired CO2 in the breath defining the treatment endpoint. We tailored treatment to each individual. There were two deaths, and 53 patients were followed up to 3 months; 50 had full testing. Of the 42 HBO-treated patients who had suffered DNS by 3 months compared with four out
of 15 treated with 100% oxygen. All DNS was treated with HBO, and fully recovered.

  (191 patients, 48% follow-up 1 month)
- 100% oxygen DNS = 1057 (57.8%)
- HBO DNS = 5164 (48.8%), (P = 0.03)

Favours HBO

Schinkelst's is the only study that found an increase in DNS in the HBO-treated group. Their treatment end-point was at 1 month, yet five patients who relapsed after hyperbaric oxygen treatment died or lost measurement at 40 days (68% 28-80 days). Based on these figures, at least three of the five patients with DNS present (100%) HBO-treated group (P = 0.13), which may have been relevant.

When analysing outcomes for DNS, five of the above studies favour HBO, one favours NBO, and one is yet to be concluded. HBO has data supporting its efficacy in treating DNS, so such data exist for NBO.

The pregnant patient

Dr. Doherty did not mention HBO as a treatment option for CO-poisoned pregnant patients. Two series from 1991 (44 and 45 patients) showed use of HBO to successfully treat pregnant patients, albeit with small subgroup numbers. In the second multicentre prospective study, three out of five in the severely poisoned group receiving high flow oxygen had adverse fetal outcomes compared with none in the HBO group. In the absence of RCT for pregnant patients, HBO is favoured as a treatment option.

Summary

We agree with Doherty's assertion that there are limitations in all studies of CO to date. Despite limitations, a strong case remains, supporting HBO in treatment of CO poisoning.

- Hyperbaric oxygen removes CO from the body faster than 100% oxygen at 2 ATA, and may shorten hospital stay of poisoned patients who are free of PEM, and psychiatric comorbidity.
- HBO guarantees that a poisoned individual will receive 100% oxygen in a dose appropriate for the patient. The authors are aware of abbreviated 100% oxygen regimens, Schinkelst publication — these are unproven.

- There is short-term recovery advantage, and potentially reduced hospital stay; however, less convincing long-term outcome advantage for HBO over NBO in preventing Persistent Early Morbidity.
- HBO has case series and basic science supporting its safety and efficacy in treating CO-poisoned pregnant patients.
- There is a treatment advantage for HBO in preventing DNS in a majority of studies. We acknowledge the need for more precise outcome definitions and further refinement of oxygen dose, to treat treatments to individual patient CO load, as well as further RCT of treatment. The RCT by Weaver and colleagues is nearing completion, and should shed further light on this complex field.

References


David K Smart
Royal Hobart Hospital, TAS, Australia
Paul D Mark
Fremantle Hospital, WA, Australia

Reply

I thank Des Smart and Mark for their interest and letter on carbon monoxide (CO) poisoning. I welcome their noting that CO has been shown to act as a second messenger, a mechanism of toxicity not included in my review.1

With regard to the statement ‘...multiple studies have failed to show any firm scientific benefit in the use of hyperbaric oxygen...’ this is still supported by the lack of adequate scientific studies, as outlined in my review. The two additional studies cited by Smart and Mark were by Ducasse et al3 and Smart et al5 (published as an abstract). The paper by Ducasse et al3 was deliberately excluded from my review, which only considered prospective trials of more than 30 patients. This study enrolled 25 patients, all with a GCS of 15, except one with a GCS of 14. There was no pre-treatment neuropsychiatric assessment. Follow-up assessment involved EEG recordings in 16 patients and cerebral blood flow in 10 patients. Smart and Mark are correct in asserting that this study found earlier recovery with hyperbaric oxygen (HBO), yet the low numbers make this a low-power study. In addition, the initial EEG were performed within the first 24 h and it is not clear whether this was prior to or after treatment in some, none or all of the patients. Of the 13 patients treated with HBO, four initially had class II EEG changes. Five of these patients were lost to follow up and it is not clear if this included any or all of the four with class II changes. Ducasse et al3 conclude by stating that when a hyperbaric facility is not immediately available, as is the case in the vast majority of Australian hospitals, that normobaric oxygen (NBO) should be administered and that they ‘...propose to treat with HBO all the patients who did not fully recover clinically two hours after breathing pure O2.’

With regard to delayed neurological sequelae (DNS), the bias and flaws in the papers by Myers et al,2 Gorman et al,7 and Smart et al5 were all elucidated in the review article. Smart and Mark have re-cited the results without listing the flaws, except with the paper by Schemkesset et al,4 a paper which is contradictory to their views on HBO. All these studies have flaws and do not stand up to rigorous scientific scrutiny; hence my assertion that there is no firm scientific basis to support HBO. The article by Weaver et al9 is ongoing and still blinded and it is difficult to evaluate the study by Smart et al5 in its abstracted form.

Raphael et al9, in a study including 629 patients, concluded that HBO had no advantage over NBO in the treatment of patients without loss of consciousness’ and that in patients with loss of consciousness, two HBO sessions had no benefit over one.

In his editorial, Emerson9 noted there are no double-blind controlled studies of the use of haemodialysis for severe methanol and ethylene glycol poisoning, but haemodialysis is still performed. This is true, but haemodialysis is more readily available in most intensive care units, including rural centres. Hyperbaric centres are few in number, with most capital cities only possessing one. To treat all cases of CO poisoning with HBO would necessitate a large number of transfers, including medical retrievals of ambulatory patients and aeromedical evacuation of rural patients. This would be at a substantial cost. Clear evidence of benefit is required to warrant such an approach.

A point well made by Smart and Mark, and also by Emerson9 is that if an HBO approach is taken on the basis of Schenkeveld et al5’s study, then this mandates 3 days of 100% oxygen therapy.
I did mention HBO as a treatment option for pregnant women, mentioning why this factor is more susceptible and quoted from him, that up to five times the duration of HBO has been recommended for pregnant patients. The debate about HBO therapy has been ongoing for many years. Even hyperbaric specialists have questioned whether HBO is a "cure in search of a disease." My review of HBO presented the evidence and discussed the flaws in this evidence. Smart and Mark argue well prove to be correct in asserting "evidence suggests a treatment advantage for HBO in preventing DSS." This does not alter the fact that the studies, at present, are scientifically flawed and are not conclusive. If there is benefit from HBO, it is still unknown whether this benefit extends to all patients or only to the most seriously poisoned. As Smart and Mark suggest, it is hoped that the study by Weaver et al may shed further light on this area.

References

Steven Doherty MB BS, FACC
Emergency Physician, Tamworth Base Hospital Tamworth, NSW, Australia

Editor's Note
This correspondence is now closed. Readers who wish to continue exploring this controversy are directed to a similar section of the argument concerning the use of hyperbaric oxygen in acute carbon monoxide poisoning in the "Letters" section of the Australian Medical Journal (2000, 116: 109-111) where Schindelbradt CB et al. respond to comments made by Weaver LK in his previous Editorial (BMJ 1999, 318: 1082-3). The SQM also concludes that 100% oxygen is the best option and Weaver LK continues to disagree with them both.

Assoc. Prof. Anthony F. Brown, Editor, Emergency Medicine

Declaring conflict of interest
I was disappointed by Dr Ronald Smith's comments in his letter to the Editor (Emerg. Med. 2000; 12: 137-8).

An otherwise important issue (conflict of interest) was clouded by an initial statement that was intended to cast doubt on the integrity of the organizers of a scientific meeting. To quote from Dr Smith's first paragraph: The recent Australasian College for Emergency Medicine and Australian Society for Emergency Medicine Scientific Conference in Auckland, New Zealand, included presentations highly favourable to the sponsors' products but denied delegates the opportunity to consider potential bias.

I would like to address the two instances in this statement. My response is based on my absolute knowledge of the organization of the Auckland Conference.

The AECM/ASEM Annual Scientific Meeting (ASM) relies on company sponsorship to subsidize costs and to keep the conference affordable to Fellows,
trainees and allied clinical personnel. The scientific content of the meeting is the responsibility of the Scientific Committee and is the basis on which the conference will be considered educational. These two aspects of the ASM are organizationally separate, although company commercial interest is obvious the basis of sponsorship. No speaker at the Auckland ASM was paid by an individual company, despite inclusion in one of the two sponsored symposia. No speaker selection was influenced by an individual company. Sponsorship monies were paid into the conference budget, from which expenses for the keynote speakers were provided according to the guidelines drafted by AKEM. All abstracts were accepted on merit and companies were not involved with the selection of speakers or content. Clearly, the Scientific Committee cannot influence the views held by the speakers with regard to particular products.

Dr Smith also states that delegates were denied the opportunity to consider potential bias. Surely the panel discussion time would have provided the opportunity to challenge any content or bias of the speakers? I trust that this clarifies the facts and reassures Fellows of the College that the ASM is conducted with full awareness of the potential for conflict of interest.

Peter Freeman
ASM 5th Conference
Appendix 2: Adult Asthma – ED Guideline

**ADULT ASTHMA - ED GUIDELINE**

Consider in those aged 14 and over

**INITIAL ASSESSMENT** (Tick the feature)

**IF ACUTELY DISTRESSED GIVE O₂ AND SALBUTAMOL NOW**

<table>
<thead>
<tr>
<th>SYMPTOMS</th>
<th>MILD</th>
<th>MODERATE any one = moderate</th>
<th>SEVERE / LIFE-THREATENING any one = severe attack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical exhaustion</td>
<td>0 No</td>
<td>0 No</td>
<td>0 Yes, may have paradoxical chest wall movement</td>
</tr>
<tr>
<td>Talks in</td>
<td>0</td>
<td>0</td>
<td>0 Words or unable to speak</td>
</tr>
<tr>
<td>Pulse rate (adults)</td>
<td>0</td>
<td>0</td>
<td>0 &gt; 120/min</td>
</tr>
<tr>
<td>Work of breathing</td>
<td>0</td>
<td>0</td>
<td>0 Working hard</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>0</td>
<td>0</td>
<td>0 Working hard</td>
</tr>
<tr>
<td>Central cyanosis</td>
<td>0</td>
<td>0</td>
<td>0 Likely to be present</td>
</tr>
<tr>
<td>Wheeze intensity</td>
<td>0</td>
<td>0</td>
<td>0 Moderate-loud/often quiet</td>
</tr>
<tr>
<td><strong>SPIROMETRY</strong></td>
<td>0</td>
<td>0</td>
<td>0 &lt; 50% or &lt; 1L or Unable to do</td>
</tr>
<tr>
<td>FEV₁ (% predicted)</td>
<td>0</td>
<td>0</td>
<td>0 &lt; 50% or &lt; 100 litres/min or Unable to perform</td>
</tr>
<tr>
<td>Peak expiratory flow rate (%)</td>
<td>0</td>
<td>0</td>
<td>0 &lt; 50% or &lt; 100 litres/min or Unable to perform</td>
</tr>
<tr>
<td><strong>SpO₂ (on air) at triage</strong></td>
<td>0</td>
<td>0</td>
<td>0 &lt; 90%; cyanosis may be present</td>
</tr>
</tbody>
</table>

**Triage nurse assessment Of severity**

- [ ] Mild
- [ ] Moderate
- [ ] Severe

**Doctor assessment of severity**

- [ ] Mild
- [ ] Moderate
- [ ] Severe

**INITIAL MANAGEMENT**

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>MILD ATTACK</th>
<th>MODERATE ATTACK</th>
<th>SEVERE &amp; LIFE-THREATENING ATTACK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O₂</strong></td>
<td>All</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Salbutamol</td>
<td>12-18 puffs MDI / spacer (preferred option) or 5mg neb for moderate x 2 doses then Q1-4hrly as needed</td>
<td>5mg Q15min</td>
<td>Consider IV</td>
</tr>
<tr>
<td>Atrovent</td>
<td>No</td>
<td>Optional</td>
<td>50C micrograms</td>
</tr>
<tr>
<td>Steroids</td>
<td>Prednisone 5-1 mg/kg Outpatient course 2-5 days Consider inhaled steroids.</td>
<td>Hydrocortisone 250mg Q6 Inpatient course.</td>
<td></td>
</tr>
<tr>
<td>Arterial blood gases</td>
<td>O Test not necessary</td>
<td>O If initial response is poor</td>
<td>O Yes</td>
</tr>
<tr>
<td>CXR</td>
<td>Not necessary unless focal signs present, no improvement with therapy or suspect pneumothorax</td>
<td>Are not routinely required. See Antibiotics guideline (pink book) before prescribing.</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Not routinely indicated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other path tests</td>
<td>Not routinely indicated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>disposition</td>
<td>Home with an interim AMP Letter for LMO</td>
<td>Admit if after at least 2 hrs of obs they retain features of a moderate attack and require further salbutamol. If improved discharge with an interim AMP and LMO letter</td>
<td>Admit</td>
</tr>
</tbody>
</table>

**Interim AMP given**

- [ ] Yes
- [ ] No

ADULT ASTHMA – TBH ED GUIDELINES 2005
# Appendix 3: Paediatric Asthma – ED Guideline

## Initial Assessment

(Tick the feature)

**If acutely distressed give O₂ and salbutamol now**

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>MILD</th>
<th>MODERATE Any one = moderate</th>
<th>SEVERE AND LIFE-THREATENING Any one = severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC</td>
<td>Normal</td>
<td>Normal</td>
<td>Agitated, confused, drowsy</td>
</tr>
<tr>
<td>Accessory muscle use</td>
<td>No to Minimal</td>
<td>Minimal to Moderate</td>
<td>Moderate to excessive</td>
</tr>
<tr>
<td>Pulse rate</td>
<td>Normal range for age</td>
<td>Tachycardia</td>
<td>Extreme tachycardia or bradycardia</td>
</tr>
<tr>
<td>Talks in</td>
<td>Sibilence</td>
<td>Phrases</td>
<td>Words/ unable to speak</td>
</tr>
<tr>
<td>Central cyanosis</td>
<td>Absent</td>
<td>Absent</td>
<td>Likely to be present</td>
</tr>
<tr>
<td>Wheeze intensity</td>
<td>Variable</td>
<td>Moderate-loud</td>
<td>Moderate-loud/often quiet</td>
</tr>
<tr>
<td>Spirometry &amp; FEF (consider over 7 yrs)</td>
<td>FEV₁ (% predicted)</td>
<td>40-60%</td>
<td>&lt; 40% or Unable to perform</td>
</tr>
<tr>
<td>Peak expiratory flow rate</td>
<td>0-60%</td>
<td>40-60%</td>
<td>&lt; 40% or Unable to perform</td>
</tr>
<tr>
<td>SpO₂ on presentation</td>
<td>&gt; 94%</td>
<td>00-94%</td>
<td>&lt; 96%, cyanosis may be present</td>
</tr>
</tbody>
</table>

Triage nurse: Severity Score: □ Mild □ Moderate □ Severe Signed: ____________________________

Doctor: Severity Score: □ Mild □ Moderate □ Severe Signed: ____________________________

## Initial Management - Assessment of Acute Attack

- If severe or life threatening—notify senior doctor immediately

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mild Attack</th>
<th>Moderate Attack</th>
<th>Severe &amp; Life-Threatening Attack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O₂</strong></td>
<td>As required</td>
<td>Yes. Continuous SpO₂ monitor.</td>
<td></td>
</tr>
<tr>
<td>Salbutamol</td>
<td>&lt; 20kg: 6 puffs MDI / spacer OR 2.5mg neb or &gt; 20kg: 12 puffs MDI / spacer OR 5mg neb</td>
<td>Continuous nebulised therapy. Consider IV infusion</td>
<td></td>
</tr>
<tr>
<td>Atrovent</td>
<td>No</td>
<td>No</td>
<td>Nebules x 3 Q. 20 minutes &lt; 20kg 250 mcg &gt; 20 kg 500 mcg</td>
</tr>
<tr>
<td>Steroids</td>
<td>Prednialone 1 mg/kg/day outpatient course 3-5 days Consider Preventer e.g. inhaled steroid</td>
<td>Hydrocortisone 4mg/Kg QS:1 Inpatient course.</td>
<td></td>
</tr>
<tr>
<td>CXR</td>
<td>Not necessary unless focal signs present</td>
<td>Necessary if no response to initial therapy or suspect pneumothorax</td>
<td></td>
</tr>
<tr>
<td>Arterial blood gases</td>
<td>Test not necessary</td>
<td>If initial response poor</td>
<td>Yes, if life threatening</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Not routinely required. Consult therapeutic guidelines (pink book) before prescribing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposition</td>
<td>Home with interim AMP Salbutamol Q 4 hrly taped Consider inhaled steroids and prednisone 3-5 days Letter for LMO</td>
<td>If after treatment and three hrs of Osb they have features of moderate asthma admit. If improved discharge as per mild.</td>
<td>Admit all patients</td>
</tr>
</tbody>
</table>

NEAHS Asthma Emergency Department Assessment and Management Plan – July 2005
# Appendix 4: Paediatric Asthma Teleform

## Hunter New England Paediatric Asthma

### CLINICAL MANAGEMENT SUMMARY

<table>
<thead>
<tr>
<th>Hospital name</th>
<th>Hospital ID</th>
</tr>
</thead>
</table>

**ED Clinician to complete**

<table>
<thead>
<tr>
<th>PRESENTATION DATE</th>
<th>PRESENTATION TIME</th>
</tr>
</thead>
</table>

**TRIAGE CATEGORY**

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

**HOSPITAL READMISSION?**

- [ ] Yes - within 48 hours
- [ ] Yes - within 24 days
- [ ] No

**SEVERITY**

- [ ] Mild
- [ ] Moderate
- [ ] Severe
- [ ] Life threatening

**MEDICATIONS GIVEN in ED (please tick)**

- [ ] Inhaled
- [ ] Oral
- [ ] Intravenous
- [ ] Not indicated
- [ ] Antibiotic [ ] Yes [ ] No

**INVESTIGATIONS/OBSERVATIONS in ED (please tick)**

- [ ] ABGs [ ] Yes [ ] No [ ] Not Indicated
- [ ] EUC [ ] Yes [ ] No [ ] Not Indicated
- [ ] SpO2 [ ] PRN [ ] Hourly [ ] Continuous
- [ ] Temp [ ] <37.2 [ ] 37.3 - 38.5 [ ] >38.5
- [ ] CXR [ ] Yes [ ] No [ ] Not Indicated
- [ ] FBC [ ] Yes [ ] No [ ] Not Indicated
- [ ] Sprometry [ ] Yes [ ] No [ ] Unable

**DISCHARGE**

- [ ] Does patient require salbutamol within three hours or less on discharge [ ] Yes [ ] No
- [ ] Prednisone script given for 3 - 5 days [ ] Yes [ ] No [ ] Not indicated
- [ ] Written Asthma plan [ ] Yes [ ] No
- [ ] Fast sheet given [ ] Yes [ ] No
- [ ] Referral [ ] LMO [ ] Paediatrician [ ] Asthma Educator [ ] None

**SEPARATION**

- [ ] Discharged home
- [ ] Admitted
- [ ] Transferred
- [ ] Died

**DISCHARGE DATE*** / *** / ***

**DISCHARGE TIME*** / ***

**Clinician SIGNATURE**

---

*Version 3 July 2005*

*When complete please fax CLINICAL MANAGEMENT SUMMARY to NEAHS CNE Paediatrics 6775 4925 [ ] FAXED - YES*