INVESTIGATING THE MANAGEMENT
OF ANAPHYLAXIS IN PHARMACY

A Growing Need for Pharmacist-Driven
Community Competence in the Preparedness and
Care of People at Risk of Anaphylaxis

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Declaration

This thesis is presented as a series of papers (which have resulted from the research and have been published in refereed journals), in accordance with rule 32 (1) of the Doctor of Philosophy Rules of The University of Western Australia.

I hereby declare that, except where specific reference is made to the works of others, the contents of this thesis are original and have not been submitted, in part or in whole, to any other University for any degree or other qualification. This thesis is the result of my own work and is my own composition. There are four original papers included in this thesis that have been co-authored. The bibliographical details of these papers and where they appear are outlined in the section ‘Publications arising from this thesis’. My contribution to each of the four papers is clearly identified in the section ‘Publications arising from this thesis’. I have the permission of all co-authors to include this work in my thesis.
Abstract

Anaphylaxis is a severe allergic reaction that is rapid in onset and can cause death. Recent and dramatic increases in prevalence have been driven by new and persisting allergies to food, insect venoms and medicines. Anaphylaxis in the community is a real concern because access to a health professional may be delayed, and death can occur within minutes.

Management of anaphylaxis in the community requires acute and long-term care. Acute treatment relies on the recognition of anaphylaxis and early use of adrenaline autoinjectors. Long-term care focuses on identification and avoidance of allergens, and preparation for recurrences. Education is crucial for both. Notwithstanding their role in supplying medicines, pharmacists can make a significant contribution to the education and care of anaphylaxis patients. In acute care, pharmacists should be ready to manage (and treat if necessary), patients who approach them suffering acute anaphylaxis. For long-term care, pharmacists prepare the patient to self-manage their anaphylaxis, through provision of advice and adrenaline autoinjectors.

This thesis investigates pharmacists’ preparedness for managing anaphylaxis, with a focus on education, knowledge and the interaction between pharmacists and people at risk of anaphylaxis. Four research areas are identified:

1. A systematic review of the literature was undertaken to investigate whether e-learning would be an effective strategy to deliver a standardised anaphylaxis education program to Australian pharmacists.

2. A controlled intervention study was conducted to determine the effectiveness of a standardised anaphylaxis education program for pharmacists. This education program was delivered online and as face-to-face lectures by the Australasian Society of Clinical Immunology and Allergy (ASCIA). Effectiveness (as knowledge
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change) was examined in tests on four occasions over 7 months, and compared with a group who did not receive training.

3. A randomised, simulated patient study was conducted to evaluate how prepared Australian community pharmacists are for anaphylaxis. Willingness to discuss anaphylaxis with the patient was also investigated.

4. The randomised, simulated patient study further assessed the intricacies of pharmacist accuracy in adrenaline autoinjector demonstration, and compared accuracy between the three different autoinjectors available at the time.

Area 1. The systematic review identified that pharmacists consider e-learning to be a highly acceptable instructional format, and that it increases knowledge immediately after training. This suggested that e-learning would be a feasible option to allow widespread delivery of standardised anaphylaxis education to pharmacists. However, the lack of validated tools in evaluation, and the absence of long-term outcome evaluations posed new questions. Therefore when implementing ASCIA anaphylaxis training for pharmacists, effectiveness was measured over 7 months using a validated tool. The review also identified that there was no evidence for application of knowledge to practice gained through e-learning. This crucial aspect of knowledge translation applies equally to knowledge gained through traditional learning methods. Therefore, examination of how pharmacists communicate anaphylaxis knowledge to patients was assessed in a real world setting.

Area 2. The controlled intervention study used a validated 12-question knowledge test administered pre-training, post-training, and 3 and 7 months after training. Pharmacists completed the e-learning program or attended an ASCIA anaphylaxis lecture. Controls
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(students in pharmacy and medicine) attended an unrelated lecture as the intervention (i.e. no training). E-learning and lecture groups performed significantly better on all post-tests compared to the pre-test, and compared to the control group (all p<0.001). E-learning and lecture scores were similar and not significantly different (p=0.6 at seven months). The proportion of learners achieving the minimum standard for anaphylaxis knowledge improved from 45% at pre-test to 87% (e-learning) and 81% (lecture-based learning) at 7 months. Knowledge of the steps for correct adrenaline autoinjector administration improved after training, but was comparatively lower (63% for e-learners and 61% for lecture-based learners) at 7 months. Demographic variables (age, main job, years since graduation, workplace location, gender) did not significantly affect knowledge scores.

Area 3: In the randomised, simulated patient study of community pharmacist practice 300 metropolitan pharmacies located in Perth, Western Australia, were randomised to 3 groups of 100 (original EpiPen, new-look EpiPen or Anapen). Using a standardised scenario, simulated patients approached pharmacists for assistance with adrenaline autoinjectors (EpiPen and Anapen), and for advice about using antihistamines in anaphylaxis. Anaphylaxis preparedness (readiness to treat acute anaphylaxis) and anaphylaxis engagement (willingness to engage the patient in discussing their anaphylaxis) were scored based on the number of predefined statements addressed by the pharmacist during the consultation (maximum score=5 for preparedness and 8 for engagement).

Of 300 pharmacies visited, 271 pharmacist consultations were included in the final analysis (88=original EpiPen, 92=new-look EpiPen, 91=Anapen). The mean anaphylaxis preparedness score was 2.39 (SD 1.17). Scores for new-look EpiPen were
significantly higher than for original EpiPen (2.75 vs 2.38, p=0.027) and Anapen (2.75 vs 2.03, p<0.001). The mean anaphylaxis engagement score was 3.11 (SD 1.73). Scores for new-look EpiPen were similar to original EpiPen and Anapen (3.11 vs 3.32; 3.11 vs 2.90, both p=0.42). Engagement was associated with preparedness. For each additional engagement point, preparedness increased by 7% (0.357 points; 95% CI: 0.291, 0.424; p<0.001).

**Area 4:** Adrenaline autoinjector demonstration accuracy was assessed against the relevant ASCIA Action Plan for Anaphylaxis, in simulated patient visits to 300 randomly selected pharmacies. Pharmacists were directly asked how to use original EpiPen, new-look EpiPen or Anapen. Of 250 pharmacist demonstrations, 46 (18.4%) accurately demonstrated all four steps on ASCIA Action Plan. Failure to state ‘do not touch the needle’ (74.8%) or ‘massage injection site’ (68.8%) reduced accuracy. However, 163 pharmacists (65.2%) accurately demonstrated the three steps required to inject adrenaline (no difference by device, p=0.15). Associations with accurate demonstration were: checking if the patient had an anaphylaxis action plan (odds ratio, OR=16.1; 95% CI: 3.86-67.3); stating to call an ambulance after use (OR=4.0; 95% CI: 1.44-11.1); or explaining the side effects of adrenaline (OR=4.5; 95% CI: 1.48-13.4).

Collectively, the findings of this thesis demonstrate that pharmacists are not fully prepared for anaphylaxis in the community. Anaphylaxis and adrenaline autoinjector knowledge is incomplete and may be effectively improved (for at least 7 months) with a standardised anaphylaxis training program. In practice (during consultations with simulated anaphylaxis patients), pharmacists were not fully prepared for anaphylaxis in the community, with only modest preparedness scores and accuracy rates in autoinjector
demonstration. This suggests a lack of knowledge or a problem with knowledge translation. Deeper understanding of anaphylaxis (including the need for anaphylaxis action plans) is associated with accurate autoinjector technique. A novel framework for Australian community pharmacists to use in anaphylaxis management may aid understanding and should be developed to improve the community care of people at risk of anaphylaxis, and those presenting with anaphylaxis.
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Original Articles

   *(See chapter 3)*

   **Author contributions:** SMS designed the protocol and subsequent study, conducted the literature search, synthesised the literature, identified and prepared the systematic review data management system, conducted data extraction, created the quality assessment criteria, synthesised and analysed the data and wrote the manuscript. AK synthesised the literature and conducted data extraction as per study methodology. FMS and RMC supervised all aspects of the study. All authors critically reviewed the manuscript for intellectual content, and read and approved the final paper.


   **Author contributions:** SMS designed the study, assisted with tool design, conducted tool validation, collected and analysed the data, interpreted results and wrote the manuscript. SV designed the intervention, conceived the tool and assisted with validation, and assisted with data collection. FMS assisted with analysis and interpretation of results. RL designed the intervention and assisted with conception of the tool. RMC assisted with study design, tool development and interpretation of results. All authors critically reviewed the manuscript for intellectual content, and read and approved the final paper.

*(See chapter 5)*

**Author contributions:** SMS designed the study, conceived the scenario and data collection tool, conducted tool validation, analysed the data, interpreted results and wrote the manuscript. BD and SD assisted with tool design and validation, and collected the data. FMS assisted with analysis and interpretation of results. RMC assisted with study design, tool development and interpretation of results. All authors critically reviewed the manuscript for intellectual content, and read and approved the final paper.


*(See chapter 6)*

**Author contributions:** SMS designed the study, conceived the scenario and data collection tool, conducted tool validation, analysed the data, interpreted results and wrote the manuscript. RL assisted with scenario design and interpretation of results. FMS assisted with analysis and interpretation of results. RMC assisted with study design, tool development and interpretation of results. All authors critically reviewed the manuscript for intellectual content, and read and approved the final paper.
Conference Presentations


Salter SM, Loh R, Vale S, Smith J, Clifford RM. ASCIA anaphylaxis training for pharmacists. 23rd ASCIA Annual Scientific Meeting; 2012 Sep 5-8; Wellington, New Zealand.


Salter SM, Cadby G, Delfante B, de Klerk S, Clifford RM. Improving the management of anaphylaxis in the community: are action plans the key? Pharmacy Australia Congress; 2012 Oct 19-21; Melbourne, Australia.


Salter SM, Loh R, Vale S, Clifford RM. Long term effectiveness of ASCIA anaphylaxis training for pharmacists. 24th ASCIA Annual Scientific Meeting; 2013 Sep 11-14; Perth, Australia (oral presentation).


Salter SM, Loh R, Sanfilippo FM, Vale S, Clifford RM. Pharmacists’ response to anaphylaxis in the community (PRAC): a randomised, simulated patient study of
pharmacist practice. 25th ASCIA Annual Conference; 2014 Sep 10-13; Melbourne, Australia (oral presentation).

Salter SM, Loh R, Sanfilippo FM, Vale S, Clifford RM. Pharmacists’ demonstration of adrenaline autoinjectors is accurate, but there is room for improvement. 25th ASCIA Annual Conference; 2014 Sep 10-13; Melbourne, Australia (oral presentation).

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Awards

2013 Finalist: The University of Western Australia 3-Minute Thesis Competition
2013 First Prize: Allergy and Immunology Update Award, 24th ASCIA Annual Scientific Meeting
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# Abbreviations

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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>AT-PAsT</td>
<td>Anaphylaxis Training Pharmacist Assessment Tool</td>
</tr>
<tr>
<td>ASCIA</td>
<td>Australasian Society of Clinical Immunology and Allergy</td>
</tr>
<tr>
<td>BEME</td>
<td>Best Evidence Medical Education</td>
</tr>
<tr>
<td>CBD</td>
<td>Central Business District</td>
</tr>
<tr>
<td>EPPI-Centre</td>
<td>Evidence for Policy and Practice Information and Coordinating Centre</td>
</tr>
<tr>
<td>IgE</td>
<td>Immunoglobulin E</td>
</tr>
<tr>
<td>IgG</td>
<td>Immunoglobulin G</td>
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<tr>
<td>PBS</td>
<td>Pharmaceutical Benefits Scheme</td>
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<td>PRAC</td>
<td>Pharmacists’ Response to Anaphylaxis in the Community</td>
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<td>PBA</td>
<td>Pharmacy Board of Australia</td>
</tr>
<tr>
<td>PRISMA</td>
<td>Preferred Reporting Items for Systematic Reviews and Meta-Analyses</td>
</tr>
<tr>
<td>T_{h}2</td>
<td>T-helper 2</td>
</tr>
<tr>
<td>US</td>
<td>United States</td>
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<tr>
<td>WA</td>
<td>Western Australia</td>
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<tr>
<td>WAO</td>
<td>World Allergy Organization</td>
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Chapter 1

Introduction
Opening statement

Allergic disorders, including anaphylaxis, atopic asthma, allergic rhinitis and eczema are common immune hypersensitivity disorders that affect billions of people worldwide.\textsuperscript{1-7} Arguably the most severe of these conditions is anaphylaxis; a rapid-onset, multisystem reaction that can cause death.\textsuperscript{8} Anaphylaxis is most frequently associated with the allergic (Immunoglobulin E; IgE) immune response, although non-IgE pathways and non-immunologic mechanisms are also implicated.\textsuperscript{9-11} In IgE mediated anaphylaxis the most common triggers are food, insect venoms and medicines.\textsuperscript{10, 11}

The incidence of anaphylaxis has dramatically increased over the past decade.\textsuperscript{12-19} More cases occur in the community than the hospital setting,\textsuperscript{20} and the greater burden of disease (driven by rising food allergies) now exists in young people.\textsuperscript{13, 15, 16, 21, 22} Early recognition of anaphylaxis and treatment with adrenaline is essential to prevent fatalities.\textsuperscript{10, 20, 23-26} However symptoms may vary from one episode to the next, and acute anaphylaxis may not always be recognised.\textsuperscript{10} Even more, the majority of people who have their own adrenaline autoinjector (such as EpiPen or Anapen) choose not to use it in an emergency,\textsuperscript{27} increasing their risk of fatal anaphylaxis.\textsuperscript{28-31} Other risk factors for fatal anaphylaxis include age (very young, very old, and adolescent), the presence of comorbid conditions (especially asthma and/or cardiovascular disease), and use of concurrent medicines (especially beta-blockers and angiotensin-converting enzyme (ACE) inhibitors).\textsuperscript{28-32} Therefore, while urgent treatment is essential, the issues of increased incidence of anaphylaxis, symptom recognition, comorbidities, and the reticence to self-administer adrenaline present unique challenges in anaphylaxis management. Beyond acute care is the need for consistent and accurate education to prepare people at risk of anaphylaxis for future events.\textsuperscript{10, 20, 23, 24}
Pharmacists in Australia are highly accessible primary care professionals who routinely supply adrenaline autoinjectors with or without a physician’s prescription. They should educate people how to recognise anaphylaxis and remind them of the need for an anaphylaxis action plan. In addition, pharmacists should teach people how to use their adrenaline autoinjector, so they will be confident to use it in an emergency. In the broader sense, community pharmacists also provide general allergy advice, treat comorbid conditions such as asthma, supply other medicines including antihistamines, and are often the first contact for people experiencing allergic reactions. There is great potential for them to play a crucial role in the community care and preparedness of people at risk of anaphylaxis, but little evidence to support this role.

Surveys conducted in United States and Canada have assessed provision of adrenaline autoinjector training, and provided a snapshot of anaphylaxis knowledge in pharmacists. They showed most people with anaphylaxis did not receive autoinjector training, and did not know how to use their adrenaline autoinjector, but sought the role of the pharmacist to include provision of both anaphylaxis education and autoinjector training. One study identified large gaps in anaphylaxis knowledge in both pharmacists and patients. They recommended the establishment of a national pharmacist education program to ensure consistency in how they teach patients. Australian research about community pharmacist attitudes to treat acute anaphylaxis showed they were unsure about how to manage anaphylaxis emergencies.

As the incidence of anaphylaxis rises and the number of patients at risk of anaphylaxis increases, there is an urgent need to investigate whether Australian community pharmacists have the requisite knowledge to be able to act confidently in an emergency, and to educate people in the community about anaphylaxis. This thesis thus explores the role of the pharmacist caring for anaphylaxis patients in the real world: Pharmacists, Patients and Pens.
1.1 Background

1.1.1 Allergic sensitisation and pathophysiology of anaphylaxis

Anaphylaxis is most commonly IgE mediated, with prior allergen exposure required for sensitisation to occur (a T helper 2 cell [T\(_{H2}\)] response). Allergens encountered for the first time are processed and presented by dendritic cells to naïve T cells in regional lymph nodes or local mucosa (Figure 1).\(^{37}\) In the presence of interleukin-4 (IL-4) these T cells acquire the characteristics of T\(_{H2}\)-cells, pro-inflammatory cells that secrete the pro-inflammatory interleukins IL-4 and IL-13. In this environment and when the T\(_{H2}\)-cells are coupled with B cells, allergen-specific IgE antibodies are produced.\(^{38}\)

After systemic distribution, these specific antibodies (along with allergen non-specific IgE) bind to the high-affinity (Fc\(\varepsilon\)RI) IgE receptor on tissue-resident mast cells, and basophils in circulation. The individual is now sensitised to the specific allergen initially encountered, although not every sensitisation will be clinically significant. A multitude of immunologic, genetic, environmental and allergen-specific factors affect the sensitisation process, and T cell regulatory mechanisms may downregulate the T\(_{H2}\) response.\(^{38}\)
Allergen sensitisation does not itself produce symptoms of allergy or anaphylaxis. Instead, re-exposure to the specific allergen to which the individual is sensitised may result in a cascade of events that manifest as the allergic response (Figure 2). When the particular allergen is re-encountered and recognised by allergen-specific IgE at the FcεRI receptor on mast cells and basophils, crosslinking and subsequent aggregation of FcεRI occurs. This activates mast cell (and basophil) degranulation. Preformed and lipid-derived mediators are released from the granules. Although many people associate allergy with histamine, the preformed mediators are more complex and varied than just histamine. They also include proteoglycans (such as heparin), proteases (such as tryptase) and various other enzymes and growth factors. The lipid-derived mediators promote the synthesis and release of prostaglandins and
leukotrienes: themselves inflammatory mediators that cause immediate and ongoing inflammation, and are involved in amplifying the allergic response.\textsuperscript{9-11, 38}

These mediators exert acute inflammatory effects in the surrounding tissue, causing vasodilation, bronchoconstriction, mucous production, increased vascular permeability and nerve stimulation.\textsuperscript{9, 10, 38} Local release of preformed mediators results in acute (and localised) symptoms of allergy, such as itching and rhinorrhea in allergic rhinitis. Rapid and systemic release of these mediators results in anaphylaxis.\textsuperscript{10, 38}

Along with preformed mediators, various cytokines, chemokines and growth factors are also released from mast cell granules. They can contribute to the acute reaction, and also promote late-phase reactions by recruiting inflammatory leucocytes (such as eosinophils, basophils and neutrophils). Late-phase reactions usually develop 2-9 hours after allergen exposure. Thus, these mediators may play an important role in
the pathophysiology of biphasic anaphylaxis.\textsuperscript{9,38}

Other immunologic mechanisms associated with anaphylaxis include the use of immune aggregates (such as intravenous immunoglobulin), biologic agents, or radiopaque contrast media; activation of complement or coagulation systems; or autoimmune mechanisms.\textsuperscript{9-11} Non-immunologic mechanisms include physical co-factors (such as stress, heat/cold, illness or exercise), and drugs (opiates, vancomycin, ethanol).\textsuperscript{9-11}

1.1.2 Pathogenesis of anaphylaxis

Anaphylaxis can occur within seconds to minutes of allergen exposure.\textsuperscript{10} The most common triggers are foods, insect venoms and medicines, although IgE sensitisation may occur to any substance and subsequently cause anaphylaxis (Table 1). Multiple triggers may exist at the same time within an individual. Young people are more likely to experience food-induced anaphylaxis, whereas insect venoms and medicines are more common triggers in adults.\textsuperscript{10,11,24,40,41} Regional variations in diet and local insect populations mean triggers may vary depending on cultural influences and geographic location.\textsuperscript{10,40-43} However, peanut, cows milk, egg and seafood remain the most common food triggers worldwide.\textsuperscript{43} Of concern is the trend for once-transient food allergies (such as egg and milk) to persist beyond childhood.\textsuperscript{6,43}
Anaphylaxis to vaccines occurs extremely rarely (estimated rate of 1 reaction per million doses).\textsuperscript{45} In the case of IgE mediated reactions, the trigger is usually an additive or residual vaccine component (such as gelatine, egg, latex, yeast or cows milk) rather than the microbial immunising agent itself.\textsuperscript{45}

Regardless of the mechanism or trigger for anaphylaxis, the mediators released from mast cells and basophils initiate and maintain the reaction in a multi-system response. The signs and symptoms of anaphylaxis occur swiftly across a dynamic
continuum (Table 2). Although sudden-onset of symptoms is characteristic of anaphylaxis, the rate of progression may vary from one person to another, and one reaction to another.\textsuperscript{10} Similarly, anaphylaxis presentation may be different from one person to the next, or within the same person, from one episode to the next.\textsuperscript{10}

Biphasic reactions (where symptoms resolve, then recur without further trigger exposure) may occur in up to 20\% of cases within 8 hours, and have been reported as late as 72 hours after the initial reaction.\textsuperscript{40} The presence of asthma complicates symptom recognition and has been associated with more than 90\% of anaphylaxis fatalities.\textsuperscript{10, 20, 30, 31, 46}

<table>
<thead>
<tr>
<th>Skin/mucosal</th>
<th>Respiratory</th>
<th>Cardiovascular</th>
<th>Gastrointestinal</th>
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<td>Pruritus</td>
<td>Dyspnoea</td>
<td>Dizziness</td>
<td>Vomiting</td>
<td>Aura of impending doom</td>
</tr>
<tr>
<td>Urticaria</td>
<td>Hoarseness and dysphonia</td>
<td>Hypotension</td>
<td>Diarrhoea</td>
<td>Sudden irritability or uneasiness</td>
</tr>
<tr>
<td>Morbilliform rash</td>
<td>Stridor</td>
<td>Arrhythmias (tachycardia, bradycardia, other)</td>
<td>Abdominal pain</td>
<td>Confusion</td>
</tr>
<tr>
<td>Angioedema</td>
<td>Wheeze</td>
<td>Shock (collapse)</td>
<td>Dysphagia</td>
<td>Tunnel vision</td>
</tr>
<tr>
<td>Periorbital oedema</td>
<td>Chest tightness</td>
<td>Pallor</td>
<td></td>
<td>Altered mental state</td>
</tr>
<tr>
<td>and itch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral oedema and itch</td>
<td>Nasal itching, rhinorrhoea, sneezing</td>
<td>Incontinence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itching of palms,</td>
<td>Cyanosis</td>
<td>Cardiac arrest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>soles, genitalia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory arrest</td>
<td></td>
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</tr>
</tbody>
</table>

Skin and mucosal symptoms are reported to occur in 80–90\% of patients with anaphylaxis, respiratory symptoms in up to 70\%, cardiovascular symptoms in up to 45\%, gastrointestinal symptoms in up to 45\%, and central nervous system symptoms in up to 15\%.\textsuperscript{24}
1.1.3 Epidemiology of anaphylaxis

With dramatic increases in food allergy over the past decade, and knowing that food is a common cause of anaphylaxis, it is not surprising that rates of anaphylaxis are also changing. Previously the lifetime prevalence of anaphylaxis has been reported as 0.05%-2%. However the true epidemiology of anaphylaxis is difficult to determine. Various factors contribute to this, including an historical lack of consensus on the definition of anaphylaxis, insufficient and inadequate International Classification of Diseases (ICD) codes, poor coding of anaphylaxis in hospital and administrative databases, and the use of varied methodologies for estimation (such as reviews of emergency department or hospital inpatient records, practitioner-based outpatient records, adrenaline autoinjector dispensing records or the use of population health datasets). Patient level factors may also contribute to underestimation of anaphylaxis rates. Variable presentation or transient symptoms may result in inaccurate diagnosis (e.g. as asthma or urticaria). Patients who experience anaphylaxis in the community and recover spontaneously may not even see a health professional, and others may be treated by a general practitioner but not visit a hospital.

At present there is no mechanism in place for mandatory recording of anaphylaxis events in Australia. Even though anaphylaxis frequently occurs in the community, most prevalence estimates are based on data from hospital admissions and represent point prevalence. In 2004-2005 the Australian prevalence of anaphylaxis (based on hospitalisations) was 10.8 per 100,000 population; the greatest burden was in children aged 0-4 years (admission rate 19.7 per 100,000 population). Compared with data from 1993-1994, anaphylaxis admissions to hospital had increased on average by 8.8% per year. The substantial increase in anaphylaxis admissions in the 0-4 years age group (from 4.1 to 19.7 per 100,000 population over the 12-year period) was largely attributed to an increase in food anaphylaxis. In 2000-2001, the prevalence of
anaphylaxis in the United Kingdom was estimated as 3.8 per 100,000 population.\textsuperscript{21} Similarly, in 2006, the prevalence of anaphylaxis in the United States was estimated at 4.7 per 100,000 population; a more than four-fold increase from 1990.\textsuperscript{15} Children aged 0-2 years and 14-18 years had the highest hospital admission rates for anaphylaxis, with food anaphylaxis occurring in 67.4\% of all cases.\textsuperscript{15} Considering all of these figures, Australia has the highest prevalence of anaphylaxis in the world.

Although the lifetime prevalence of anaphylaxis is more difficult to estimate, in 2011 (in the United States) this was estimated as 1.6-6.7\% \textsuperscript{51} (range based on ‘certain’ and ‘highly likely’ categorisation of anaphylaxis); a significant rise on estimates from 2006.\textsuperscript{13}

These changes in point and lifetime prevalence suggest an increasing incidence of anaphylaxis, especially in young people. Food anaphylaxis is a major concern because food allergies are tending to persist more now than ever before.\textsuperscript{6} Already 10\% of one-year old children in Australia have challenge-proven food allergy.\textsuperscript{48} Between 1995 and 2006 there was a 7-fold increase in specialist referrals (and a 5-fold increase in hospitalisations) for food anaphylaxis in Australian children aged 0-5 years.\textsuperscript{42} As these children reach adulthood with their allergy intact, there is expected to be a dramatic and sustained rise in anaphylaxis in the general population. Behind them, a potential wave of new cases is forming.\textsuperscript{6, 43, 49}

Considering the difficulty people face in avoiding anaphylaxis triggers, this new epidemic should become a major concern in the community. First-time reactions can be fatal and death can occur within minutes (median 30 minutes for food, 12 minutes for insect stings and 5 minutes for medicines).\textsuperscript{30} Therefore, preparedness is of utmost importance – in anaphylaxis recognition and diagnosis, treatment and long-term management.
1.1.4 Diagnosis of anaphylaxis

The diagnosis of anaphylaxis must be made clinically. This can be difficult for patients, carers and health professionals during the stressful period of acute anaphylaxis, and often anaphylaxis is not formally diagnosed until after the event. There are no laboratory tests or biomarkers that unequivocally diagnose anaphylaxis. Elevation of serum histamine and tryptase occurs during anaphylaxis. However, changes are not consistent for different triggers, and across different age groups, making them unreliable biomarkers for diagnosis in the acute phase (tryptase may aid diagnosis after the event).24, 52 Platelet-activating factor (PAF) correlates better with anaphylaxis severity than either histamine or tryptase, however concentrations return to baseline within 20 minutes, thus this biomarker is not practically useful.52 Because there is no simple test to confirm anaphylaxis either at the time of presentation or afterwards, recognition of the features of anaphylaxis is of prime importance in initial events, then formal diagnosis and pattern recognition are important after the episode.10,11,24

Diagnosis depends on the presenting signs and symptoms, preceding activities (consideration of trigger/s), and any response to treatment.10,24 In the community this can be complicated by common differential diagnoses, such as acute asthma, acute generalised urticaria, syncope or panic attack.20, 24, 52 The pattern of sudden-onset and rapid progression of symptoms remains characteristic of anaphylaxis, although symptoms may vary by age. In elderly people, cardiovascular symptoms associated with insect venom or medicine-based triggers are typical; whereas young people are more likely to be atopic, and present with respiratory symptoms associated with food triggers.52 Generalised urticaria may appear alarming but is not diagnostic, nor is its absence: in at least 10% of anaphylaxis cases, there may be no skin signs.20, 44 Furthermore, many commonly used medicines and drugs can affect recognition of anaphylaxis. These include sedating H1-antihistamines, sedatives, antidepressants,
ethanol, and recreational drugs. Anaphylaxis may be hard to diagnose in infants and young children, and subtle signs such as persistent cough or hypotonia may not be recognised as part of anaphylaxis.

The key to diagnosis relies on pattern recognition of the collective circumstances and symptoms around the episode of anaphylaxis. Clinical criteria for diagnosis are shown in Table 3. Usually more than two body systems are required to be involved for diagnosis. However, in some circumstances, and after exposure to a known trigger, anaphylaxis may be diagnosed based on involvement of a single body system (for example sudden onset of cardiovascular symptoms after insect sting).
Table 3. Clinical criteria for diagnosing anaphylaxis.24

Anaphylaxis is highly likely when any ONE of the following three criteria is fulfilled, with acute onset of symptoms (minutes to hours):

1. Sudden illness involving the skin, mucosal tissue or both (e.g. generalised urticaria, itching, flushing, swollen lips/tongue/uvula)

AND AT LEAST ONE OF THE FOLLOWING

a) Respiratory compromise (e.g. dyspnoea, persistent cough, bronchospasm/wheeze, stridor)
b) Reduced blood pressure or associated symptoms of end-organ dysfunction (e.g. hypotonia, syncope, collapse, incontinence)

OR – after exposure to a likely allergen for that person

2. TWO OR MORE OF THE FOLLOWING

a) Sudden illness involving the skin, mucosal tissue or both (e.g. generalised urticaria, itching, flushing, swollen lips/tongue/uvula)
b) Respiratory compromise (e.g. dyspnoea, persistent cough, bronchospasm/wheeze, stridor)
c) Reduced blood pressure or associated symptoms of end-organ dysfunction (e.g. hypotonia, syncope, collapse, incontinence)

OR – after exposure to a known allergen for that person

3. Reduced blood pressure

a) Infants and children: low systolic blood pressure (age-specific) or greater than 30% decrease in systolic blood pressure
b) Adults: systolic blood pressure less than 90 mmHg, or greater than 30% decrease in that person’s baseline blood pressure

Table adapted from: Simons F et al. World Allergy Organiz J. 2011.24

After the acute event, it is essential that a specialist allergist verify the diagnosis of anaphylaxis: to identify the trigger, plan long-term management and institute risk reduction strategies.20 Management of people with a diagnosis focuses on allergen avoidance and preparedness to treat future events. However for obvious reasons, first time anaphylaxis in the community needs urgent recognition and care. In this context rapid first aid is crucial, and pharmacists are being sought – most likely because they are easily accessible health professionals known to stock adrenaline autoinjectors – as a treatment destination by people with acute anaphylaxis. Therefore pharmacists must be able to recognise the signs and symptoms of anaphylaxis, and be prepared to perform the dual role of acute and long-term care.
1.1.5 Management of anaphylaxis

Anaphylaxis is a medical emergency requiring prompt treatment of acute events and long-term care to prevent and treat recurrences.²⁴ Importantly, there is no test that can predict the severity of future reactions.²⁴ People with a diagnosis of anaphylaxis may misinterpret their risk for a fatal reaction based on their first reaction, complicating preparedness for self-treatment (in fatal anaphylaxis, just 20% of cases had a history of previous severe allergic reactions, while the other 80% had only previously experienced mild to moderate allergic reactions.³⁰,⁴¹)

The World Health Organization, the World Allergy Organization and all region-specific anaphylaxis guidelines state adrenaline is the drug of choice for treating acute anaphylaxis.²⁴, ⁵³⁻⁵⁶

Adrenaline prevents and relieves the manifestations of mast cell and basophil degranulation through effects on most body systems. It quickly increases the force and rate of cardiac contraction, relaxes bronchial smooth muscle, decreases mucosal oedema, increases blood pressure and relieves urticaria.⁵⁷⁻⁶⁰ Because adrenaline causes vasodilation in skeletal muscle and is quickly absorbed from this highly vascular environment, intramuscular injection to the mid-anterolateral thigh is recommended in initial treatment of anaphylaxis.¹⁰, ²⁴ In the community, this is best achieved using adrenaline autoinjectors, and these devices (although not universally available) are widely prescribed worldwide.³³, ⁵⁷, ⁵⁹, ⁶¹, ⁶² There are two adrenaline autoinjectors available in Australia: EpiPen and Anapen. Both devices are available in low- and higher-dose forms (0.15mg for children>12 months, up to 20kg; and 0.3mg for children
over 20kg and adults). Repeated doses (every 5-15 minutes) may be required depending on the response to initial treatment and severity of the episode.\textsuperscript{24}

Despite the widespread recommendation for adrenaline as first line treatment, and the evidence that delayed adrenaline is associated with fatal anaphylaxis, it is apparent that patients, carers and clinicians frequently underuse it, and instead administer antihistamines, beta\textsubscript{2} agonists or glucocorticoids as first line treatment.\textsuperscript{24, 27, 47, 63-66} These medicines are considered second line or ancillary agents and should never be administered either first line or as the sole treatment in anaphylaxis.\textsuperscript{8, 10, 24} Table 4 shows the rationale for, and limitations associated with the use of second-line medicines in anaphylaxis.
<table>
<thead>
<tr>
<th>Medicine</th>
<th>Rationale</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁ receptor antagonists (antihistamines)</td>
<td>Relieve itching, flushing, urticaria, angioedema, eye and nose symptoms.</td>
<td>Do not prevent or relieve laryngeal oedema and upper airway obstruction, hypotension or shock. First generation antihistamines are associated with CNS depression, which may complicate interpretation of anaphylaxis.</td>
</tr>
<tr>
<td>Beta₂ adrenergic agonists</td>
<td>Aid lower respiratory wheeze, cough and shortness of breath.</td>
<td>Do not prevent or relieve laryngeal oedema and upper airway obstruction, hypotension or shock.</td>
</tr>
<tr>
<td>Glucocorticoids</td>
<td>Powerful anti-inflammatory effect: reduce production of pro-inflammatory mediators and may reduce symptom recurrence after a severe reaction or a reaction with marked or persistent wheeze. Theoretically may prevent protracted or biphasic anaphylaxis.</td>
<td>Onset of action too slow to treat acute anaphylaxis (several hours for effect). No conclusive evidence for prevention of protracted or biphasic anaphylaxis.</td>
</tr>
</tbody>
</table>

The erroneous use of these medicines in anaphylaxis is of particular relevance to community pharmacists. Patients may purchase antihistamines and beta₂ agonists (i.e. salbutamol) from pharmacies in Australia without a prescription. Some patients may not recognise their symptoms as anaphylaxis, and instead seek to purchase these over-the-counter medicines to relieve rashes or bronchospasm, during early anaphylaxis.

Management of anaphylaxis does not end with resolution of the reaction or confirmation of the diagnosis by a specialist allergist. Despite best efforts to avoid triggers, there is no guarantee that further episodes of anaphylaxis will not occur. Inadvertent exposure, and sometimes even deliberate exposure to triggers (e.g. in adolescents), may cause recurrent anaphylaxis. For this reason, people with a history of anaphylaxis should be prescribed and supplied with two (of the same) adrenaline
autoinjectors to carry at all times. Individuals, their families and carers should be taught why, when and how to use these devices, and regular updates are essential.\textsuperscript{10, 20, 24, 57}

A systematic approach to care, including avoidance of triggers and management of acute anaphylaxis is facilitated with the use of a personalised written anaphylaxis emergency plan (an anaphylaxis action plan).\textsuperscript{70} This document identifies anaphylaxis triggers, distinguishes the symptoms of anaphylaxis from mild-to-moderate allergic reactions, instructs patients and carers how and where to administer adrenaline, and highlights the importance of calling an ambulance/attending hospital after using adrenaline.\textsuperscript{20, 53, 70, 71} As with patients, health professionals should be prepared for anaphylaxis emergencies with a well displayed, written emergency protocol,\textsuperscript{24, 69} although no pharmacy-specific protocols exist.

Management of comorbid conditions that increase the risk of fatal anaphylaxis is important.\textsuperscript{10} Pharmacists regularly supply medicines for patients with asthma, other respiratory and cardiovascular diseases, and participate in optimising the health of these patients. Furthermore, pharmacists should remind patients not to depend on antihistamines for treatment of anaphylaxis, especially patients who are familiar with them.\textsuperscript{20}

Education at all levels is necessary for each of these management considerations: acute care, trigger avoidance, supply of adrenaline autoinjectors, the need for an anaphylaxis action plan, and optimising management of comorbid conditions. Indeed, education of patients, carers and health professionals is considered the most important preventive strategy for anaphylaxis recurrence, and is a priority of the World Allergy Organization.\textsuperscript{24, 25, 52, 57} In the community, pharmacists may play a vital role educating patients about their anaphylaxis, and instructing them when and how to use adrenaline.
1.1.6 Role of the pharmacist

Consider the complexities of anaphylaxis – an illness that is not contagious yet has insidious beginnings; where harm is associated with the goings-on of everyday life; where the burden of disease is increasingly borne by the young who may also grow old with it; where urgent treatment is critical to save lives and preparedness through education is vital for all. People at risk of anaphylaxis are usually well, yet they have a chronic disease. Unlike other chronic conditions (and notwithstanding approaches such as immunotherapy to remodel the immune response), anaphylaxis only requires drug treatment during acute events. In any year, 1 in 12 people who have had anaphylaxis will experience a recurrence. But even these people will not be as practiced with adrenaline as those taking medicines for chronic disease on a daily basis. Many of them (and their carers), will never have been shown, will choose not to use, or will simply forget how to correctly use, their autoinjector. Even more, this is complicated by recent changes in adrenaline autoinjector availability in Australia. Before the listing of Anapen in 2010, EpiPen was the sole device available in Australia. A new-look EpiPen became available in 2011, and for a period all three devices were sold (original EpiPen, new-look EpiPen, Anapen). As a result, people who had adrenaline autoinjectors prescribed before 2010 had to change from one device to a different device after original EpiPen was withdrawn in 2012.

In Australia, pharmacists are the sole suppliers of adrenaline autoinjectors to patients (and their carers). It is during this supply that they can opportunistically engage the patient to practice autoinjector administration and discuss anaphylaxis. Such opportunities are becoming more frequent: spending on adrenaline autoinjectors through the PBS in Australia, grew from AU$188,000 in 2003 to almost AU$13 million in 2013; a 70-fold increase independent of any increase in unit price.

Although treatment with adrenaline is only necessary during acute anaphylaxis,
education about anaphylaxis should occur continuously.\textsuperscript{10, 20} Patients need to know about anaphylaxis action plans, adrenaline autoinjectors, trigger avoidance, and what to do if anaphylaxis recurs. They need to be told to always carry their adrenaline autoinjector and to replace it when it expires.\textsuperscript{10, 20, 24} Many will perceive antihistamines to be a safer option than adrenaline and will use them during an emergency, despite adrenaline being safe (in correct autoinjector use), even in children.\textsuperscript{56, 57, 59} All patients need to know exactly how to use and store their specific autoinjector, and that EpiPen and Anapen are not interchangeable. Patients who have asthma as well as anaphylaxis especially need optimal asthma control, and this is facilitated through asthma and anaphylaxis education, and identification of patients with worsening asthma, such as those presenting in pharmacy for frequent salbutamol purchases. Patients need to know to call an ambulance after anaphylaxis even if they have recovered, in case of biphasic reactions.\textsuperscript{10, 20, 24}

While patients must ultimately take responsibility for their own anaphylaxis management, this comprehensive requirement for knowledge is universal. Pharmacists have the accessibility, time and place to make a significant contribution educating patients with a history of anaphylaxis. Moreover, pharmacists must be prepared to assist people who approach them suffering acute anaphylaxis. They need the skills to discern anaphylaxis from other allergy, and a thorough understanding of acute and long-term management.

However, the evidence for such involvement is limited. In a US survey of people who had experienced anaphylaxis (n=1885), almost half had not received adrenaline autoinjector training.\textsuperscript{27} Another US survey assessed the need for anaphylaxis and autoinjector training by community pharmacists (n=1887), and found oral counselling was not provided for over 86\% of pharmacist-supplied adrenaline autoinjectors.\textsuperscript{34} Irrespective of this, patients in the study supported a greater role for the
community pharmacist to provide both anaphylaxis education and autoinjector training.\(^{34}\) A Canadian assessment \((n=1083)\) of anaphylaxis knowledge found 62% of pharmacists did not know the signs and symptoms of anaphylaxis and 45% did not understand the importance of calling an ambulance after anaphylaxis. The same study assessed autoinjector technique in patients \((n=1448)\) and found 63% did not know how to use their device and only 56% had received autoinjector training.\(^{35}\) This study called for standardised anaphylaxis and autoinjector training to be made available for pharmacists, to ensure consistency in teaching patients,\(^{35}\) a critical part of anaphylaxis preparedness. Until recently, such programs did not exist in Australia.\(^{81}\) Moreover, anaphylaxis has not always been a component of Australian pharmacy degree curricula. Therefore there is a potential gap in anaphylaxis knowledge amongst Australian pharmacists.

There is a lack of research evaluating Australian pharmacist practice, knowledge, and their preparedness for emergencies in the context of anaphylaxis. Given the unpredictable nature of anaphylaxis, the dramatic rise in new cases of anaphylaxis, the potential for first-time reactions to be fatal,\(^{30}\) and the prospect that some patients choose pharmacies as a treatment destination, there is a need to identify if pharmacists are ready to manage anaphylaxis. This thesis explores pharmacists’ real-world preparedness for anaphylaxis, with particular consideration to education, knowledge and the interaction between pharmacists and people at risk of anaphylaxis.
1.2 Scope of this research

This research project considered the holistic role of the pharmacist in caring for people at risk of anaphylaxis. The overarching feature of all aspects of anaphylaxis care is education, and this project begins by assessing e-learning as a strategy to deliver a standardised anaphylaxis education program to Australian pharmacists. The research then explores pharmacists’ knowledge about anaphylaxis, and the impact of a standardised anaphylaxis education program on their knowledge. Beyond this, the research focuses on the interaction between pharmacist and patient, concentrating on how the pharmacist educates the patient about anaphylaxis and adrenaline autoinjectors. Collectively these broad concepts measure pharmacist preparedness for the community care of people at risk of anaphylaxis, by focussing on the following four research areas, and associated research questions:

Area 1:
How is effectiveness assessed in evaluations of pharmacy e-learning programs, and is it an effective instructional format in pharmacy education?

Area 2:
What level of knowledge do pharmacists possess about anaphylaxis and adrenaline autoinjectors? Is it possible to improve their knowledge using a standardised anaphylaxis education program? Are there differences in knowledge gained based on how the program is delivered (e-learning or face-to-face lectures)? Are knowledge gains sustained long-term? Can pharmacists gain enough knowledge to be able to manage anaphylaxis or demonstrate adrenaline autoinjectors (evidenced by reaching a minimum level of achievement), and is this also sustained long-term?
Area 3:
Beyond knowledge assessments, what evidence exists for anaphylaxis preparedness in Australian community pharmacists? How do pharmacists educate people at risk of anaphylaxis under conditions of usual practice? Are pharmacists willing to engage in discussion (about anaphylaxis) with people at risk of anaphylaxis? Are there any features of the pharmacist-patient exchange that may improve pharmacist preparedness for anaphylaxis?

Area 4:
Given pharmacists supply all adrenaline autoinjectors to patients in Australia, how accurate are they at demonstrating correct use of these devices, under usual conditions of practice? Further, did the change in adrenaline autoinjector availability in Australia (2010-2011) affect demonstration accuracy? Are there any features of the pharmacist-patient exchange that may improve pharmacists’ accuracy in adrenaline autoinjector demonstration?

1.3 Structure of this thesis
This thesis is submitted as a series of papers (which have resulted from the research and have been published in refereed journals), in accordance with rule 32 of the Doctor of Philosophy Rules of The University of Western Australia. The thesis comprises seven chapters: an introductory exposition, a methodological statement, four scientific papers, and a general discussion chapter to conclude. Each of the scientific papers contains an independent introduction, methods, results and discussion section, and some overlap in content is unavoidable to enable the papers to be read by the wider community as
discrete entities. Each chapter is referenced separately to acknowledge the relative contribution of prior works and expedite identification of related evidence.

The current chapter presents an overview of the problem, explaining the pathophysiology and pathogenesis of anaphylaxis, its epidemiology, diagnosis and management. This chapter highlights the importance of education and preparedness for anaphylaxis in the community and maps out the important role of the pharmacist in community care. Four research areas with focused research questions are identified in this chapter.

Chapter 2 presents an overall methodological summary of the research. Methods included a systematic review of the literature, a controlled intervention study, and a randomised cross sectional simulated patient study. Expanded methodology is presented in each of the scientific papers.

Chapter 3 addresses the first set of research questions, and considers for the first time, the effectiveness of e-learning in pharmacy education. This systematic review of the literature was conducted to ascertain how effectiveness in this setting is measured, to synthesise the evidence for each measure, and to determine overall if e-learning is an effective form of instruction in pharmacy education. The synthesis provides evidence that e-learning is effective, and identifies areas for further effectiveness research. Importantly, the evidence in chapter 3 supports the application of an anaphylaxis e-learning intervention and provides effectiveness measures to assess the intervention.

Chapter 4 addresses the second set of research questions through a controlled, interrupted-time series study of a standardised anaphylaxis education program. This chapter assesses baseline then change in anaphylaxis knowledge over time, after implementation of the education intervention. The assessment thus applies and extends a key effectiveness measure identified in chapter 3 – long-term knowledge change.
Additionally, this chapter introduces level of achievement as a new effectiveness measure (identified as a gap in chapter 3).

Recognising that knowledge does not guarantee application to practice, chapter 5 investigates the third set of research questions using a randomised, simulated patient approach. This chapter considers the content and features of the interaction that occurs between a pharmacist and a person at risk of anaphylaxis, in the community pharmacy setting. Key outcome measures that demonstrate translation of knowledge to practice are presented, including anaphylaxis preparedness and willingness to engage in a discussion about anaphylaxis. Features of the interaction that impact on preparedness are considered. One particularly important feature is the ability to accurately demonstrate an adrenaline autoinjector. This chapter identifies a potential problem with adrenaline autoinjector demonstration, and thus overall anaphylaxis preparedness among pharmacists.

Chapter 6 delves further into the problem with adrenaline autoinjector technique, and in doing so addresses the fourth set of research questions. This chapter continues to report the research commenced in chapter 5, closely assessing if and how pharmacists demonstrate each of the steps required for accurate autoinjector use. The cause of the potential problem is identified, and considered in context of demonstration accuracy by other health professionals. For the first time, this chapter identifies that pharmacists have the highest rates of adrenaline autoinjector demonstration accuracy (compared with physicians, patients and carers), although there is still room for improvement.

The final chapter presents a cohesive discussion of the four research areas, including critical consideration of the results. This section integrates the findings of the research with implications for policy and practice; and points to new areas for research as a result of the findings of this thesis.
1.4 Bibliography


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Chapter 2

Methodological Summary
2.1 Introduction

The studies performed to address the four key research areas outlined in Chapter 1 are included in the thesis as a series of original papers, forming Chapters 3-6. These studies included a systematic review of the literature, a controlled interrupted time-series intervention study, and a randomised cross sectional simulated patient study. This chapter describes the research and analysis methods applied in the studies.

2.2 Ethics approvals

All studies were approved by the Human Research Ethics Committee of The University of Western Australia (approval numbers RA/4/1/4850 and RA/4/1/5440). All participants in the overt research provided written, informed consent. Participants in the simulated patient research were unaware of their participation. These participants were not identified, the risk for harm was low, and the benefits from the research outweighed any risks of harm associated with not seeking consent. Therefore, we were granted a waiver of informed consent for that study.

2.3 Research methods

2.3.1 Systematic review of the literature

A systematic review of the literature was undertaken to address the first research area. The protocol for the review was published on the PROPSERO International prospective register of systematic reviews (see Appendix 1). The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement. In order to identify effectiveness measures used in pedagogical research, a separate review of the literature was undertaken prior to the systematic review. This identified Kirkpatrick’s model as a potential framework upon which to guide
effectiveness measures, (adopted in 2009 by the Best Evidence Medical Education Collaboration [BEME] as a grading standard for literature reviews).\textsuperscript{2, 3} Based on this model, three primary outcomes (learning, behaviour and results), and one secondary outcome (reaction) were identified for the review.

The systematic review was conducted using the Web-based systematic review software, DistillerSR (Evidence Partners Incorporated, Ottawa, Canada). Two reviewers independently assessed and then abstracted data using a series of dedicated forms that I developed based on the Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre) data extraction and coding tool for education studies.\textsuperscript{4} These forms were piloted and refined prior to data abstraction, and applied through DistillerSR (see Appendix 2). I contacted the authors of publications for which additional data was required to answer questions included in the data abstraction forms.

A quality assessment tool was developed for the systematic review based on three published tools,\textsuperscript{4-6} and the assessment embedded within the data abstraction forms in DistillerSR. (This tool is published as an appendix to Chapter 3). Further, the impact of each intervention, and the strength of findings for each study were considered based on two published scales.\textsuperscript{2, 3} Kirkpatrick’s hierarchy was used to assess the impact of each intervention in terms of learning, behaviour or results.\textsuperscript{3} The BEME weight of evidence rating scale (strength 1=no clear conclusions can be drawn, not significant; 2=results ambiguous, but there appears to be a trend; 3=conclusions can probably be based on the results; 4=results are clear and very likely to be true; 5=results are unequivocal) was used to assess the strength of findings of each study, and was an aid to assist overall study quality assessment.\textsuperscript{2}

This review is presented as an original paper in chapter 3 of the thesis.
2.3.2 Controlled intervention study

A controlled interrupted time-series study of a standardised anaphylaxis education program, was undertaken to address the second research area. There were three arms: e-learning intervention, face-to-face lecture intervention and control. The key outcome measure was knowledge change over time. The secondary outcome measure was level of achievement, defined as achieving a score of 9/12 (75%) or better on the knowledge assessment test.

ASCIA developed the anaphylaxis education program in consultation with key pharmacy stakeholder groups and other members of the pharmacy profession (including the candidate). The e-learning and lecture programs were equivalent in content and time required for completion.

Intervention participants included Pharmacists (registered with the Pharmacy Board of Australia (PBA)), pharmacy interns (provisionally registered with PBA and completing practice hours under the direct supervision of a registered pharmacist), and pharmacy students (enrolled in an approved course of study in the field of pharmacy at an Australian university). Control participants were students of medicine or pharmacy at the University of Western Australia.

Knowledge change was assessed using a 12-question test, the Anaphylaxis Training Pharmacist Assessment Tool (AT-PAsT) (see Appendix 3), which was developed and validated prior to first use. This used a combination of multiple-choice, yes/no, and order-the-steps questions to measure knowledge of the prevention, identification, and management of anaphylaxis in the community setting. An expert group of 10 allergy and immunology physicians and 2 clinical pharmacists (including the candidate) developed the test questions and assessed content validity. Modifications to wording and content changes were made to 2 questions. Face validity was evaluated
in a group of 15 pharmacists and 5 pharmacy students, and all agreed they understood the questions and response options. This test was piloted in a group of 67 pharmacists, then redeveloped and re-validated prior to use in the larger study. The final AT-PAsT was formatted to create four separate versions: a pre-test, a post-test, a 3-month test and a 7-month test. Questions and response options were re-ordered on each version to reduce practice effect. The test was administered in paper copy and/or online on four separate occasions (identified above) over a 7-month period. Level of achievement was assessed based on overall scores attained by participants relative to the minimum standard (score of 9/12 (75%) or better).

This study is presented as an original paper in chapter 4 of the thesis.

2.3.3 Randomised cross-sectional simulated patient study

A randomised cross-sectional simulated patient study of pharmacist practice was conducted to address the third and fourth research areas.

A random sample of 300 pharmacies (located within a 20km radius of the Perth Central Business District, and listed on the Pharmacy Registration Board of Western Australia Premises Register), was selected using a random number generator. Using the same generator, pharmacies were randomly assigned to original EpiPen, new-look EpiPen or Anapen groups, and then each group randomly allocated to one of three, trained research assistants. In a full-day training session prior to the study, the research assistants learnt a scenario, practised the role of the simulated patient, and learnt a ‘script’ so that all responses to pharmacist questions were the same. EpiPen and Anapen trainers were used to teach research assistants correct device demonstration, and their device technique was assessed to ensure accuracy. The research assistants carried two of
the same new, unmarked, adrenaline autoinjector devices to each pharmacy visit. The autoinjectors were replenished as required to appear ‘new’.

The data collection for this study captured preparedness variables (broadly: allergy assessment, autoinjector demonstration, antihistamine recommendations); adrenaline autoinjector demonstration variables (broadly: materials used for demonstration, use of references, steps used in demonstration, errors or omissions in demonstration and other advice provided); and demographic variables (broadly: pharmacy environment, pharmacist age and gender). The scenario and data collection form were piloted and minor adjustments made prior to the main study. The final scenario and data collection form are presented in Appendices 4 and 5.

At each visit during the study, the research assistants enacted the scenario of a newly diagnosed anaphylaxis patient. They asked the pharmacist to show them how to use their adrenaline autoinjector, and for advice regarding the use of antihistamines in anaphylaxis. Immediately after the visit (away from the premises) the assistants completed the data collection form. This data was subsequently entered into a Microsoft Excel file.

The primary outcome measure for the third research area was anaphylaxis preparedness. This was defined based on key statements from ASCIA\textsuperscript{9} and the World Allergy Organization.\textsuperscript{10, 11} Anaphylaxis preparedness (or readiness to treat acute anaphylaxis) considered symptom recognition, the need to call an ambulance after treatment, anaphylaxis action plans, adrenaline autoinjector use and antihistamine recommendations. Willingness to engage the patient in a discussion about their anaphylaxis was a secondary outcome, and concepts from the Australian Professional Practice Standards,\textsuperscript{12} and National Competency Standards Framework for Pharmacists in Australia\textsuperscript{13} were added to those used for the primary measure, in the definition of this
outcome. These concepts included allergen awareness, the need for specialist review, performing a hands-on autoinjector demonstration (as opposed to verbal counselling), providing written information, checking autoinjector expiry and explaining the side effects of adrenaline. Additionally, factors that may impact on anaphylaxis preparedness (such as demographic factors, type of autoinjector and anaphylaxis engagement) were considered during statistical analysis.

The key outcome measure for the fourth research area was accurate demonstration of the adrenaline autoinjector. Being able to correctly use an adrenaline autoinjector is the most crucial factor in immediate treatment of anaphylaxis in the community, and a central component of long-term strategies for the management of anaphylaxis. Accurate demonstration was defined based on the steps listed on the relevant ASCIA Action Plan for Anaphylaxis; Appendix 6. Secondary outcomes, including variation in accuracy by device, and predictors for accurate demonstration were investigated during statistical analysis.

This study is presented as two separate original papers in chapters 5 and 6 of the thesis. The paper for chapter 5 considers the questions around holistic preparedness for anaphylaxis, and identifies a potential problem with autoinjector demonstration. The paper for chapter 6 delves into this problem while providing detailed evidence for autoinjector demonstration accuracy.

2.4 Analytical methods

Qualitative and quantitative methods were used to analyse the data from my research.

In the systematic review of the literature, the included studies differed significantly by design, intervention, duration, assessment method, and outcome. Few studies reported sufficient data to enable calculation of a combined effect size, and there was limited response to requests for data. Therefore it was not appropriate to conduct a
meta-analysis for any of the identified effectiveness measures. Instead, a meta-narrative approach to synthesis was adopted. Broad themes of effectiveness measures reported in each study were iteratively categorised using qualitative methods, to yield a detailed thematic map of e-learning effectiveness in pharmacy education.

The remainder of the research data was analysed quantitatively. All quantitative analyses were performed using SPSS v21 [IBM, New York, United States of America], and statistical tests reported as two-sided p-values at the 5% level of significance.

A linear mixed-effects model with post-hoc pairwise analysis (T-test) was used to evaluate knowledge change within and between groups in the controlled study of the standardised anaphylaxis training program for pharmacists.

In the simulated patient study, multiple linear regression was used to identify the extent to which various factors impact on anaphylaxis preparedness. One-way ANOVA with post-hoc pairwise analysis (T-test) was used to evaluate differences in anaphylaxis preparedness score by autoinjector group.

Univariate and multivariate binary logistic regression was performed to identify the impact of various features of the consultation with the pharmacist on accurate adrenaline autoinjector demonstration.

Comparison of categorical variables across groups in the controlled intervention and simulated patient studies was undertaken using the Pearson chi-squared test or Fisher’s exact test. McNemar’s test was used for within group comparisons.

All statistical models considered the influence of demographic and other potentially related variables on the outcome measure. Additional details regarding specific statistical tests, including power calculations are included in the relevant chapters.
2.5 Bibliography


Chapter 3

A Systematic Review of the Effectiveness of E-learning in Pharmacy Education

Presented as published in *The American Journal of Pharmaceutical Education*.


3.1 Background

This chapter aims to address the first set of research questions by identifying and evaluating the literature on effectiveness of e-learning in pharmacy education. Of particular interest are the outcome measures used to assess e-learning programs, and whether these demonstrate that e-learning is an effective instructional format in pharmacy education.
Chapter 3

Investigating the Management of Anaphylaxis in Pharmacy

3.2 Publication


REVIEWS

Effectiveness of E-learning in Pharmacy Education

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Submitted October 21, 2013; accepted December 16, 2013; published May 15, 2014.

Over the past 2 decades, e-learning has evolved as a new pedagogy within pharmacy education. As learners and teachers increasingly seek e-learning opportunities for an array of educational and individual benefits, it is important to evaluate the effectiveness of these programs. This systematic review of the literature examines the quality of e-learning effectiveness studies in pharmacy, describes effectiveness measures, and synthesizes the evidence for each measure. E-learning in pharmacy education effectively increases knowledge and is a highly acceptable instructional format for pharmacists and pharmacy students. However, there is limited evidence that e-learning effectively improves skills or professional practice. There is also no evidence that e-learning is effective at increasing knowledge long term; thus, long-term follow-up studies are required. Translational research is also needed to evaluate the benefits of e-learning at patient and organizational levels.

Keywords: pharmacy education, e-learning, knowledge assessment, computer instruction, internet

INTRODUCTION

The fundamental purpose of pharmacy education is to provide pharmacy students with the knowledge and skills to become pharmacists, and then to enable pharmacists to remain competent in the profession. The traditional pedagogy involving face-to-face instruction has evolved alongside the maturation of the Internet. Increasingly, pharmacists, pharmacy students, and pharmacy educators encounter teaching and learning opportunities beyond the classroom, with more and more content delivered online.1-5 Historically, online learning (using information and communication technologies) represented one facet of e-learning, while computer-based learning (using standalone multimedia such as a CD-ROM) represented another. Now e-learning is defined as learning conducted through an Internet process.6,7

E-learning programs are truly ubiquitous, and for this reason they offer attractive solutions to educating large numbers of geographically diverse populations. They allow standardized educational content to be easily distributed and updated. Learners gain control over time and place of learning, while programs provide automated real-time feedback for teachers and learners. Moreover, rather than move away from teacher-centered pedagogy, educators enhance and extend existing curriculums with e-learning opportunities, and learners embrace this.8,9,10 However as e-learning becomes a common feature in pharmacy education, the need to demonstrate its effectiveness increases.

Measuring and defining effectiveness of complex interventions, such as e-learning is difficult.11-13 In 1969, Donald Kirkpatrick proposed a 4-level model for evaluation of training programs.14 Further in 2009, the Best Evidence Medical Education (BEME) Collaboration adopted (and termed the levels) “Kirkpatrick’s hierarchy,” as a grading standard for literature reviews.15 In both instances, the levels may be simply defined as (1) reaction, (2) learning, (3) behavior, and (4) results. Reaction is a measure of program satisfaction. Learning is a measure of attitudes, knowledge, or skills change as a result of the program. Behavior is represented by the transfer of learning to the workplace. Finally, results are a measure of how the learning has changed organizational practice or patient outcomes.

Several reviews have evaluated the effectiveness of e-learning in the health profession, some with and others without applying the concepts of Kirkpatrick’s hierarchy.8,9,16-22 However, there are no reviews of the effectiveness of e-learning in pharmacy education. We conducted a systematic review to identify and evaluate the literature on effectiveness of e-learning in pharmacy.
education. We used Kirkpatrick's hierarchy to guide outcome measures. Our primary aim was to determine effectiveness in terms of learning, behavior, and results. Our secondary aim was to assess effectiveness as reactions to e-learning programs.

METHODS

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement.\textsuperscript{24} The protocol for the review is published elsewhere.\textsuperscript{24} We defined specific criteria to allow a focused review of the effectiveness of e-learning in pharmacy education (Table 1). We included any effectiveness research that evaluated e-learning programs in undergraduate, postgraduate, and continuing professional development pharmacy education. We did not set limits on study design, language, or year of publication.

A senior reference librarian at The University of Western Australia's Medical and Dental Library with expertise in conducting systematic literature reviews was consulted as part of the process to develop a comprehensive search strategy (Table 2). Databases were searched from inception to June 4, 2013. The review was conducted using the Web-based systematic review software, DistillerSR (Evidence Partners Incorporated, Ottawa, Canada). All identified citations were uploaded to DistillerSR and duplicates were removed. We developed forms for title/abstract and full-text screening according to the stated eligibility criteria, and pilot tested them before implementing them in study selection. Two reviewers independently and in duplicate screened all titles and abstracts. Potentially eligible abstracts, abstracts where reviewers disagreed, or abstracts with insufficient information were retrieved for full text review. Two reviewers then assessed the eligibility of each study in duplicate, and a final list of studies was determined. Agreement between reviewers was measured using Cohen's kappa (weighted kappa for title/abstract screen was 0.75, and for full text screen, 0.88, estimated using DistillerSR). Conflicts were resolved by consensus. Reasons for exclusion were documented and are presented in Figure 1.

Two reviewers independently abstracted data using a series of dedicated forms we developed based on the Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre) data extraction and coding tool for education studies.\textsuperscript{25} These forms were piloted and refined prior to data abstraction, and applied through DistillerSR. We assessed reviewer agreement in data abstraction using Cohen's kappa, where 0=no agreement and 1=complete agreement. We abstracted data on study characteristics (study aims, location, participants, intervention topic, and assessment; kappa range 0.53-1); study design and methodology (sampling and recruitment, blinding, power, funding; kappa range 0.43-1); data collection and analysis (how data were collected, use and reliability of tools, statistical analysis; kappa range 0.48-1); and outcomes. As the focus of this review was on effectiveness, we sought information for outcomes that measured change after the e-learning intervention was delivered. The form for learning outcomes identified knowledge or

<table>
<thead>
<tr>
<th>Table 1. Definitions Used in Conducting a Systematic Review of eLearning in Pharmacy Education</th>
</tr>
</thead>
</table>
| **E-learning program**  
Participants | Educational program accessed through the Internet.  
Pharmacists, intern (or trainee) pharmacists, preregistration pharmacists, pharmacy students. Studies evaluating any other person or population receiving or using a pharmacy e-learning program were excluded.  
Intervention | Any pharmacy e-learning program. Hybrid interventions were defined as a combination of face-to-face and e-learning components in one course. Blended interventions were defined as a combination of multiple training methods, including e-learning, in one course.  
Comparator | 1. 'No training': no other learning activity.  
2. 'Traditional learning': Same topic delivered as face-to-face teaching or through books. This evaluated the effectiveness of the e-learning education program.  
3. 'Traditional learning': Different topic delivered as face-to-face teaching or through books. This evaluated the effectiveness of the e-learning education program. Studies without comparator groups were also included.  
Primary Outcomes | 1. Learning: change in attitudes, knowledge or skills after training.  
2. Behaviour: transfer of learning to the workplace (includes willingness to apply learning in the workplace).  
3. Results: Changes in organisational practice (e.g. in delivery of care) and patient outcomes as a result of the program.  
Secondary Outcomes | 1. Reaction: learners' views about the e-learning program, including experiences and satisfaction with the topic and e-learning technology. |

Table 2. Search Strategy Used in Conducting a Systematic Review of e-Learning in Pharmacy Education

<table>
<thead>
<tr>
<th>Search Databases</th>
<th>MEDLINE, EMBASE, Web of Knowledge, ERIC, PsycINFO, Science Direct, CINAHL, IPA, and Google Scholar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review databases</td>
<td>Evidence Based Medicine, Joanna Briggs Institute</td>
</tr>
<tr>
<td>Grey literature databases</td>
<td>Mednar, Open Grey, Scirus</td>
</tr>
<tr>
<td>Reference list peering</td>
<td>All included studies</td>
</tr>
<tr>
<td>Search Terms</td>
<td>Pharmacist, intern pharmacist, internship nonmedical, pharmacy, preregistrant, professional</td>
</tr>
<tr>
<td>Participants</td>
<td>preregistered, preregistration, trainee, pharmacy student, pharmacy, professional</td>
</tr>
<tr>
<td>Intervention</td>
<td>E-learning, e-training, learning, education, blended, virtual, web-based, education</td>
</tr>
<tr>
<td>Pharmacy continuing, computer assisted instruction, computer assisted learning, computer, internet, online, distance education, flexible, program</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>Knowledge, skills, practice, change, acceptability, satisfaction</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Effectiveness, comparative effectiveness research, evaluation, outcome assessment, test, assessment, educational measurement</td>
</tr>
</tbody>
</table>

Medical subject heading (MeSH) terms and keywords were searched in accordance with database indexing practices. Searches were iteratively refined to suit different databases and to improve accuracy within each database.

*Preregistrant, preregistered/preregistration refers to graduate pharmacists who held provisional registration as a pharmacist with the Pharmacy Board of Australia and who were undertaking supervised practice hours under the direct supervision of a registered pharmacist.*

Database-specific searches are available from the authors upon request.

skills change, and problem-solving ability (kappa range 0.55-1). The form for behavior and results outcomes identified willingness to change behavior or practice change, and organizational change or patient benefit (kappa range 0.64-1). The form for reaction outcomes identified satisfaction, attitudes and opinions (kappa range 0.48-1). Finally and where relevant, we contacted authors by e-mail to request missing data.

We expected the studies to be diverse, to include both qualitative and quantitative designs, to consist in the majority as noncomparative studies, and by the very nature of e-learning interventions, to be limited in their ability to conceal the intervention from the participant. Further, acknowledging that quality assessment of education intervention studies is complex, we considered no single published quality assessment tool to be appropriate.

Figure 1. Systematic review flow. Studies may have contributed more than one effectiveness outcome measure. Reaction = satisfaction and course opinions. Learning = change in attitudes, knowledge or skills (including perceptions of these). Behavior = practice change (actual or willingness to change). Results = organizational change and patient benefit.
Table 3 summarizes the characteristics of pharmacy e-learning effectiveness studies. Every study assessed a different learning topic, although 3 studies included diabetes within their focus.20-32 Six studies (35%) assessed effectiveness of e-learning in pharmacists,32-37 10 studies (59%) assessed pharmacy students (of which 1 included preregistration pharmacists),31,36-46 and 1 study assessed both pharmacists and pharmacy students.30 The number of participants in each study ranged from 17-190.

Fourteen studies (82%) delivered e-learning in more than 1 format. The most common interventions were online modules, with or without simultaneous audio. Online reading materials, synchronous and asynchronous lectures, virtual patients, compulsory discussions (with peers or teachers), online feedback systems, and multimedia vignettes were also presented. Six studies (35%) included traditional methods, such as face-to-face lectures, workshops or small-group activities, as part of a blended or hybrid approach.31,36-40,45 Five studies (29%) included a comparator group (non-Internet teaching on the same or different topics, or no training). There was significant variation in setting, including mode of delivery (continuing education, distance learning, university core and elective units, university courses, and pre-registration training), and duration of the intervention (range: 25 minutes to 1 academic year of education).

Effectiveness was measured using a variety of objective and subjective assessments, including pre-post knowledge tests, curriculum tests, mock patients, rating scales, semi-structured interviews, and written or online surveys. All objective assessments were analyzed quantitatively; while subjective assessments were analyzed qualitatively and/or quantitatively. We identified 3 effectiveness outcomes based on Kirkpatrick’s hierarchy, which were reaction, learning, and behavior, with 13 studies (76%) reporting more than 1 of these outcomes. A further 19 effectiveness themes emerged through the iterative process. These were refined and presented as a thematic map of e-learning effectiveness in pharmacy education (Figure 2).

Reaction was assessed subjectively, with different instruments and scales in each study. E-learning programs were considered beneficial in improving knowledge and confidence, and stimulating interest.30,31,35,37,39,40,44,46 Courses were evaluated in terms of their functionality, which was measured as time taken to complete the course.35,38,39 online navigation (programs were easy to use and user-friendly),32,33,35,37,39,44 course presentation (courses were acceptably designed and integrated),31,35,37,40,46 and technical issues (online access, and quality of recordings).31,35,45,46 The majority of pharmacists and pharmacy students considered their e-learning
### Table 3. Description of Studies Included in a Systematic Review of eLearning in Pharmacy Education

<table>
<thead>
<tr>
<th>First Author, Year, Country</th>
<th>E-Learning Topic</th>
<th>Participants</th>
<th>E-Learning Intervention</th>
<th>E-Learning Setting</th>
<th>Comparator Intervention</th>
<th>Outcomes¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erickson, 2001, US</td>
<td>Asthma inhaler technique</td>
<td>PS: 42</td>
<td>Online video streaming and text with animations for demonstration</td>
<td>One hour lecture from a university core unit that included respiratory medicine</td>
<td>Didactic lecture on the same topic, or no training</td>
<td>K, S</td>
</tr>
<tr>
<td>Elliott, 2004, Australia</td>
<td>Pharmaceutical calculations, pharmacy law</td>
<td>PP: 108</td>
<td>Online modules, online reading materials, online asynchronous discussions as part of a blended course (included 8 days of FTF education)</td>
<td>23-26 weeks of online distance education in a Pharmacy Preregistration Course</td>
<td>NC</td>
<td>R, PB</td>
</tr>
<tr>
<td>Lust, 2004, US</td>
<td>Veterinary therapeutics</td>
<td>PS: 17</td>
<td>Online images and text</td>
<td>Two elective credit hours in undergraduate pharmacy</td>
<td>NC</td>
<td>PC, PK, PB</td>
</tr>
<tr>
<td>Freeman, 2006, US</td>
<td>Drug information</td>
<td>PS: 124</td>
<td>Online asynchronous lectures with supplementary oral narration or written descriptive captions, and learning quizzes, delivered as part of a blended program</td>
<td>Four one-hour lectures as part of a first year Pharm D program</td>
<td>NC</td>
<td>PB</td>
</tr>
<tr>
<td>Hall, 2006, US</td>
<td>Diabetes</td>
<td>PS: 109</td>
<td>Online modules, online asynchronous lectures</td>
<td>Twelve modules as a standalone university elective course</td>
<td>NC</td>
<td>PB, K, WP</td>
</tr>
<tr>
<td>Sweet, 2006, US</td>
<td>Diabetes medicines</td>
<td>P: 29</td>
<td>Online modules, Internet-based feedback system</td>
<td>Three one-hour modules as part of a CE program</td>
<td>NC</td>
<td>R, K</td>
</tr>
<tr>
<td>Congdon, 2007, US</td>
<td>First-year doctor of pharmacy (PharmD) program</td>
<td>PS: 132</td>
<td>Online asynchronous lectures, synchronous videoconferencing as part of a hybrid course (including small-group FTF activities)</td>
<td>Full year of a university course conducted at a newly opened satellite campus</td>
<td>The same course delivered by traditional methods at the main campus</td>
<td>R, K</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>First Author, Year, Country</th>
<th>E-Learning Topic</th>
<th>Participants</th>
<th>E-Learning Intervention</th>
<th>E-Learning Setting</th>
<th>Comparator Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hughes, 2007, Canada</td>
<td>Laboratory values</td>
<td>P: 25</td>
<td>Online reading materials, online asynchronous discussions as part of a blended learning course (also included a 2 day FTF workshop)</td>
<td>12-week CPD course, including three distance learning sessions</td>
<td>NC</td>
<td>R, PC, K, PRAC</td>
</tr>
<tr>
<td>Flowers, 2008, US</td>
<td>Over-the-counter eye and ear drops; inhaler devices</td>
<td>PS: 79</td>
<td>Online modules with simultaneous synchronized scrolling text (presented as 5 vignettes)</td>
<td>One month Advanced Community Pharmacy Practice Experience</td>
<td>No training</td>
<td>K</td>
</tr>
<tr>
<td>Crouch, 2009, US</td>
<td>Advanced cardiovascular pharmacotherapy</td>
<td>PS: 158</td>
<td>Online modules, online synchronous lectures, online reading materials, online discussion boards as part of a blended course (25% online)</td>
<td>Eight 35-minute drug-focused lectures and six 25-minute introductory presentations in a university elective unit</td>
<td>NC</td>
<td>R, K</td>
</tr>
<tr>
<td>Lancaster, 2009, US</td>
<td>Over-the-counter medicines: gastrointestinal conditions; obesity</td>
<td>PS: 97</td>
<td>Online modules, online asynchronous lectures, as part of a hybrid lecture model including in-class active learning</td>
<td>Six lectures of a university core unit</td>
<td>Didactic lectures on a different topic; previous year’s scores</td>
<td>R, K</td>
</tr>
<tr>
<td>Tsugihashi, 2009, Japan</td>
<td>Core competency in clinical research</td>
<td>P: 42</td>
<td>Online synchronous lectures, Internet-based feedback system</td>
<td>Twenty-three 60-minute lectures in a DL program</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>Battaglia, 2010, US</td>
<td>Medication therapy management and diabetes care</td>
<td>P: 42, PS: 80</td>
<td>Online modules, online reading materials, online virtual patient, “drop box” for documentation</td>
<td>Four virtual patient interactions in a CE program or university pharmacy core unit</td>
<td>NC</td>
<td>PB, K, WP</td>
</tr>
<tr>
<td>Legris, 2010, Canada</td>
<td>Pharmacotherapy assessment in chronic renal disease</td>
<td>P: 52</td>
<td>Online virtual patient – interactive clinical vignettes</td>
<td>60 minute CE program</td>
<td>No training</td>
<td>R, K, S</td>
</tr>
</tbody>
</table>

(Continued)
Investigating the Management of Anaphylaxis in Pharmacy

Chapter 3


course to be relevant and practical. \(^{30,32,33,35,37,39,45,46}\) One study reported dissatisfaction with online lectures in pharmacy students. \(^{44}\)

Learning was assessed objectively and subjectively. Of 11 studies assessing knowledge change, all reported a significant improvement in knowledge immediately after e-learning. \(^{30,32,34,35,36,38,39,41,43,45,46}\) However, the magnitude of the gain varied considerably from study to study (range 7% to 46%). Comparative studies assessing knowledge change demonstrated e-learning to be equivalent to lecture-based learning and superior to no training. \(^{35,38,41,43}\) One skills assessment reported significant gains (24% increase after training; adjusted compared to control), \(^{35}\) while another reported superior skills after e-learning in a posttest compared to control. \(^{41}\) Significant gains in self-perceived confidence or knowledge after e-learning varied in magnitude, depending on whether a 5- or 7-point rating scale was used. Most ratings improved by 1-2 points on each scale, representing a change between 14% and 40%. \(^{34,37,45,46}\)

Behavior was assessed subjectively, as direct application of knowledge or skills to the workplace. \(^{34,46}\) or willingness to change practice. \(^{30,31}\) Although intended behavior change was reported, the intention varied across studies, depending on the educational topic.

The quality of each study was rated as low (0-4), moderate (5-7), or high (8+), with a maximum score of 10 points. The mean quality for all included studies was 5.7 (Table 4).

For all studies, the most common flaws in methodology were selection bias and associated poor external validity (narrow sampling frame, convenience sampling, self-selection, use of financial incentives, lack of randomization). Lack of validated tools \(^{30,33,34,36,38,40,45}\) and/or control group \(^{30,34,36,37,39,40}\) limited the quality of 11 of the 17 studies. Only 4 studies reported research questions or hypotheses. \(^{30,33,41,45}\) Two studies had significant loss (40% or greater) at follow-up (posttest). \(^{31,35}\) Almost all studies included self-report (subjective) data; in uncontrolled studies, confounders affecting opinions were not identified or considered in study design or analysis. Most studies did not clearly explain analyses or fully report results of analyses (eg, significant differences claimed based on pooled data, where pooled results were not reported).

When compared to quality scores, there was no apparent relationship between the impact of e-learning interventions and quality, based on Kirkpatrick’s hierarchy. Conversely, BEME strength of findings for each study showed a trend, with higher-quality studies receiving higher ratings on the BEME scale.

Figure 2. Thematic map of e-learning effectiveness concepts in pharmacy education.

DISCUSSION

This review is the first to comprehensively examine the effectiveness of e-learning in pharmacy education. Effectiveness is a complex, theoretical construct; here we used Kirkpatrick’s hierarchy to guide the development of a detailed e-learning effectiveness map in pharmacy education. Our primary interest was effective learning. Eleven studies evaluated knowledge change. Ten studies conducted pre- and post-intervention tests only, and 1 study conducted an additional 2 follow-up tests.59 All reported a significant improvement in knowledge after e-learning, although the magnitude of the gain varied widely (7% to 46%). This confirms that e-learning in pharmacy education is effective at increasing knowledge immediately after training. Additionally, in comparisons, e-learning was as effective as traditional learning and superior to no training. These results concur with the breadth of literature demonstrating effectiveness of e-learning in developing knowledge, in other professions.5,9,16-22 However, long-term knowledge change as a result of e-learning remains unknown.

Table 4. Quality of Studies Included in a Systematic Review of eLearning in Pharmacy Education

<table>
<thead>
<tr>
<th>First Author, Year*</th>
<th>Reporting/3</th>
<th>Design And Methodology/6</th>
<th>Analysis/1</th>
<th>Overall Quality Score/10</th>
<th>Kirkpatrick’s Hierarchy (Impact of Intervention)*</th>
<th>BEME Rating (Strength of Findings)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congdon, 2007*58</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1, 2b</td>
<td>4</td>
</tr>
<tr>
<td>Crouch, 2004*59</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1, 2b</td>
<td>3</td>
</tr>
<tr>
<td>Elliott, 2004*40</td>
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Overall quality score: 0-4: low; 5-7: moderate; 8- high. Mean (SD) quality for all studies: 5.70 (1.40); for comparator studies: 6.60 (1.67); for non-comparator studies: 5.33 (1.15); for studies evaluating standalone e-learning: 6.20 (1.40); for hybrid/blended courses: 4.83 (1.37).

* Levels: 1 = satisfaction or opinions; 2a = modification of attitudes; 2b = measured knowledge or skills change; 3 = practice change. No studies measured level 4 concepts.

* BEME ratings: 1 = no clear conclusions; 2 = results ambiguous; 3 = conclusions probably based on results; 4 = results are clear and likely to be true; 5 = results are unequivocal.
Attitudinal change (assessed as pre and post e-learning ratings) evaluated professional confidence in performing tasks and perceived knowledge. The evidence, while significant, was realistically limited. In all cases, assessment was subjective, gleaned through questionnaires with rating scales and survey instruments. Improvements in attitude were seen immediately after e-learning. However, the results need to be interpreted with caution; scale format data should not be analyzed on an item-by-item basis, and ordinal data is at risk of distortion when reported as mean scores, as occurred in 4 studies. Only 1 study employed sufficient methodological rigor to objectively report a positive change in skills after e-learning. To conduct objective skills or practice assessments is costly and time consuming, and requires greater dedication than objective knowledge assessments. However, the goal of quality education must be to improve skills and practice, and research should be directed to this. There were no e-learning effectiveness studies for organizational change or patient benefit – the highest level in Kirkpatrick’s hierarchy. Translational research is required to determine the benefits of e-learning at this level.

Our secondary aim was to assess effectiveness as reactions to e-learning programs. Effectiveness measures for reactions included perceived benefits of e-learning, relevance of the specific e-learning course, and e-learning functionality. Most pharmacists agree that e-learning formats stimulate interest, provide flexible alternatives to traditional methods, and are easy to use. There is limited evidence for acceptance of technology used in e-learning, although technology is central to the process. This may be because the Internet is so inherently a part of everyday life that the details of technology are overlooked in research. Poor recordings or difficult access can lead to bad learning experiences. Further, as students (as part of the millennial generation) embrace other e-learning opportunities such as social media applications or massive open online courses (MOOCs), continued evaluation of e-learning technology will be essential. Finally, courses were presented in a myriad of formats, and satisfaction with course design and educational content was generally high.

Overall, the findings of these studies show that learners consider e-learning a highly acceptable instructional format in pharmacy education. However, we acknowledge the risk that ratings may have been subject to response bias and that respondents’ impressions may have changed over time after completing the e-learning course. Opinions may be affected by external factors, especially in times of stress (e.g., pharmacy students may score ratings differently after examinations compared to usual coursework); however, this is true for any instructional format. Finally, what we observed is missing from e-learning satisfaction research is the impression of the educator.

Our study has several limitations. We limited the eligibility criteria for inclusion in the study to those studies that reported evaluations of the effectiveness of e-learning in pharmacy education. Other research evaluating effectiveness alongside different constructs may have been overlooked. Although 2 reviewers independently abstracted the data, differences in study interpretation may have impacted the data obtained, as evidenced by the low to moderate agreement within some of the data extraction levels. Although overall quality was moderate, study methodological quality was generally low. Three particular flaws stood out: selection bias, lack of control groups, and lack of validated tools. Most studies were conducted within a narrow sampling frame, did not employ appropriate control groups, and used only partially validated or non-validated tools, thus limiting internal and external validity. We attempted to synthesize results for a group of studies that held only 2 commonalities: pharmacy and e-learning. Interventions, topics, duration, and setting were different for every study. However, while this may have affected combination of results, the fact that e-learning was effective in different environments may support generalizing these results. Further, we acknowledge that all included studies reported significant (and positive) effects, and that publication bias was likely to exist. Lastly, we synthesized the evidence for pharmacists and pharmacy students as one. We recognize each have distinct learning needs, motivations, and environments. As pharmacy students progress to pharmacists, learning styles may change. Future reviews should identify specific aspects of effective e-learning for each population.

In the context of the broader literature, our review adds e-learning as an effective instructional method in pharmacy education, to the evidence that it is effective for other health professions. Individual e-learning programs should continue to be evaluated for effectiveness, not to answer the question of whether e-learning works in pharmacy, but to inform educators and decision makers that the program itself is effective. There are 2 key reasons why this matters. First, e-learning programs are often developed for large-scale distribution; thus, confidence that the program will effectively teach (often complex) pharmacy topics is essential. Second, e-learning programs may not always be subject to the same scrutiny that traditional programs undergo, especially those...
developed by smaller organizations specifically for a target audience.

Finally, 13 of the 17 studies reviewed evaluated more than 1 effectiveness measure, in some cases using multiple methods. Problems with reporting, methodology, and thus quality may stem from this multiple outcome approach, suggesting that effectiveness studies of e-learning in pharmacy education are trying to address too many questions at once. Now that we know e-learning is effective in the short-term, it may be more useful to see well-conducted research that reports the long-term effectiveness of e-learning in pharmacy education (defined by 1 or 2 measures only) rather than broad snapshots of immediate impact.

CONCLUSIONS

E-learning has been studied as an instructional format across a range of pharmacy education topics and contexts for decades, yet until now there have been no reviews on the effectiveness of e-learning in pharmacy education. In this review, we found e-learning to be effective at increasing knowledge immediately after training for all topics and in all contexts. Therefore, we can generalize that e-learning in any context should improve knowledge. E-learning in pharmacy education was a highly acceptable instructional format for pharmacists and pharmacy students, although this measure of effectiveness, by its nature was assessed subjectively and is open to criticism. There is little evidence that e-learning improved skills or professional practice and no evidence that e-learning is effective at increasing knowledge long term. There is room for improvement in the quality of e-learning effectiveness research in pharmacy. Properly validated tools, follow-up research, and translational research are required to answer new questions about the effectiveness of e-learning in pharmacy education.

ACKNOWLEDGEMENTS

Sandra Salter is the recipient of a University Postgraduate Award and UWA Top-Up Scholarship, provided by The University of Western Australia. There were no other funding arrangements for this study.

REFERENCES


### Appendix 1. Criteria for Quality Assessment of Included Studies

<table>
<thead>
<tr>
<th>Quality criteria</th>
<th>Reporting</th>
<th>Design and Methodology</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study context and aims clearly stated</td>
<td>Type of study (e.g., RCT, ITS, cross-sectional) and rationale clearly stated</td>
<td>Analyses conducted clearly stated</td>
<td></td>
</tr>
<tr>
<td>E-learning and control interventions (including their delivery) clearly stated</td>
<td>Measurements timed appropriately for stated outcomes</td>
<td>Rationale for analyses explained</td>
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<tr>
<td>Intervention and control participants clearly stated</td>
<td>Sampling frame, recruitment and sample selection clearly stated and appropriate</td>
<td>Analysis control for confounding/bias</td>
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<tr>
<td>Completeness of follow up stated</td>
<td>Design control for bias (incentives, ethics approval, allocation method, blinding, power and sample size calculation, funding)</td>
<td>Unexpected outcomes reported</td>
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<tr>
<td>Prespecified outcomes fully reported</td>
<td>Use and validation of tools clearly stated</td>
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<tr>
<td>Bias assessed</td>
<td>Reporting bias, attrition bias</td>
<td>Selection bias, detection bias</td>
<td>Reporting bias, performance bias</td>
</tr>
</tbody>
</table>

Maximum designated points: 15 points  
Calculated maximum score: 3 points

| | 30 points | 6 points |
| Maximum designated points | 4 points | 1 point |

* Scoring was embedded in DistillerSR, with designated points scored for each criterion. Total designated points were converted to a maximum of 3 points for reporting, 6 points for design and methodology, and 1 point for analysis.
3.3 Key points from this chapter

- The measures used to evaluate the effectiveness of e-learning in pharmacy education are those of learning, reaction and behaviour, although behaviour has been used infrequently and only measured subjectively.

- Learning has been measured objectively (as knowledge gain and skills change); and subjectively (as perceived benefits or increased confidence).

- There is good evidence for immediate knowledge gain after e-learning, but no evidence that this gain is sustained beyond the immediate period after learning.

- Only one paper applied robust research to measure skill development as a result of e-learning, thus the evidence for skills change after e-learning is limited.

- Reactions to e-learning have been frequently assessed. Amongst those using e-learning, the vast majority find it a highly acceptable instructional format in pharmacy education.

- There is limited evidence for behavioural change. Where researched, learners agree immediately after e-learning that they intend to change behaviour or practice. However, this is subjective and representative only of the point in time immediately after training. Just one study investigated whether learners perceived they had actually changed practice (as opposed to intent).

- There is no current evidence that the knowledge gained from e-learning courses is translated to practice or has improved patient outcomes.

- E-learning effectiveness research has generally been of moderate quality. Wider sampling frames, randomisation, validated tools and the use of controls is needed to improve quality.

- Assessment of individual e-learning programs should continue. Long term knowledge gain and translation of knowledge to practice are key areas for research.
Chapter 4

Implementation and Evaluation of ASCIA Anaphylaxis Training for Pharmacists

Presented as published in *The American Journal of Pharmaceutical Education*.


4.1 Background

The systematic review of the literature reported in Chapter 3 showed that both pharmacists and pharmacy students consider e-learning a highly acceptable instructional format in pharmacy education.\(^1\) In the context of anaphylaxis, education is a crucial component of patient care.\(^2^\)\(^-^\)\(^4^\) For pharmacists to educate people about anaphylaxis, they must first have the knowledge to do so, and then be retrained at an appropriate interval to maintain their knowledge. This was especially important in 2011 when adrenaline autoinjector devices in Australia were changing.

The aim of ASCIA anaphylaxis training for pharmacists is to provide a standardised anaphylaxis education program that is consistent with ASCIA programs delivered to doctors, other health professionals, schools, childcare staff and the general community.\(^5^\) It is difficult to deliver such a program in a timely manner to a geographically diverse population. Chapter 3 showed there is evidence that e-learning is an effective instructional format in pharmacy education and increases knowledge in the
short term. Therefore, delivery of ASCIA anaphylaxis training for pharmacists online is a feasible option to overcome the barriers to learning of time and place. While the evidence for acceptability of e-learning is strong, the evidence for long-term knowledge gain after e-learning is limited.

This chapter aims to address the second set of research questions by assessing pharmacist knowledge about anaphylaxis and adrenaline autoinjectors, implementing a standardised anaphylaxis training program, and then reassessing knowledge. Of particular interest is long-term effectiveness of the training program.

The specific aim of this study was to evaluate the effectiveness of ASCIA anaphylaxis training for pharmacists after implementing it as an e-learning program. As no ASCIA training has been evaluated for effectiveness, the relative effectiveness of online ASCIA anaphylaxis training for pharmacists was measured in comparison with ASCIA lecture training and no training. The most suitable effectiveness measure in this circumstance was learning. This was assessed as immediate and long-term knowledge change, and level of achievement.
Chapter 4

4.2 Publication


**INSTRUCTIONAL DESIGN AND ASSESSMENT**

**Long-term Effectiveness of Online Anaphylaxis Education for Pharmacists**

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Submitted December 16, 2013; accepted February 26, 2014; published September 15, 2014.

**Objective.** To evaluate the long-term effectiveness of an Australasian Society of Clinical Immunology and Allergy (ASCLA) anaphylaxis e-learning program compared to lectures or no training.

**Design.** A controlled interrupted-time-series study of Australian pharmacists and pharmacy students who completed ASCLA anaphylaxis e-learning or lecture programs was conducted during 2011-2013. Effectiveness was measured using a validated test administered pretraining, posttraining, and at 3 and 7 months after training.

**Assessment.** All learning groups performed significantly better on all posttests compared to the pretest, and compared to a control group (p<0.001). The proportion of e-learners achieving the minimum standard for anaphylaxis knowledge improved from 45% at pretest to 87% at 7 months.

**Conclusion.** The ASCLA e-learning program significantly increased anaphylaxis knowledge. The high proportion of participants achieving the minimum standard at 7 months indicates long-term knowledge change.

**Keywords:** e-learning, knowledge, evaluation, Australasian Society of Clinical Immunology and Allergy, adrenaline auto-injector.

**INTRODUCTION**

Anaphylaxis is a severe, progressive allergic reaction that is rapid in onset and may cause death.1 The incidence of anaphylaxis has dramatically increased over the past decade,2-6 with more cases occurring in the community setting than in the hospital setting.10 Early diagnosis of anaphylaxis and treatment with adrenaline is essential to prevent fatalities, and deaths are more common in patients with a history of asthma.10-14 Adrenaline is internationally recognized as the first-line treatment for anaphylaxis, with auto-injector devices universally recommended as first aid for anaphylaxis occurring in the community setting. Prescriptions for adrenaline auto-injector devices should be accompanied by a device-specific emergency action plan.11,14-19

In Australia, pharmacists supply adrenaline auto-injectors to patients who present a physician’s prescription, or to those patients without a prescription when an individual therapeutic need is established by the pharmacist. In addition, pharmacists sell these devices to Australian schools and childcare services to facilitate emergency treatment.20-23 With each distribution, pharmacists should educate patients (or their agents) about anaphylaxis, confirm they have a device-specific ASCIA Action Plan for Anaphylaxis, and advise them regarding the correct use and storage of the adrenaline auto-injector.14,20,24 Pharmacists also provide collaborative care (usually with a family physician or specialist physician) to patients with comorbid conditions including asthma, offer advice about and sell medicines for the treatment of allergies, and are sometimes called upon to provide first aid for patients with acute anaphylaxis. Changes to devices in Australia, including the addition of Anapen in 2010 and the change of EpiPen to a new-look device in 2011, highlighted the potential for patient confusion and the importance of up-to-date pharmacist advice. Therefore, pharmacists need to have a thorough knowledge of anaphylaxis as well as adrenaline auto-injectors.

In 2011, the Australasian Society of Clinical Immunology and Allergy (ASCLA) launched “ASCLA
Anaphylaxis e-training for pharmacists to meet the need for accurate, consistent anaphylaxis education. This e-learning package complemented existing ASCIA anaphylaxis e-training programs for schools and childcare services and other health professionals. The importance of ensuring that this e-training is effective at increasing anaphylaxis knowledge is paramount to reducing the risk of fatal anaphylaxis in the community. Long-term effectiveness is of prime importance because the incidence of anaphylaxis is increasing and errors in management because of waning knowledge may result in a poor outcome for the patient.

Effectiveness studies of e-learning in health professionals’ education indicate e-learning is as effective as traditional methods at increasing knowledge immediately after training. However, there is little evidence to support the long-term effectiveness of e-learning to enhance knowledge, or to meet a minimum knowledge requirement, such as a minimum pass score. In this study, we sought to evaluate the immediate and long-term impact of ASCIA Anaphylaxis e-training for pharmacists on anaphylaxis knowledge, compared to ASCIA anaphylaxis lecture training or no training. We hypothesized that ASCIA Anaphylaxis e-training for pharmacists would be as effective as ASCIA anaphylaxis lecture training at increasing short and long-term knowledge, meeting a minimum standard for anaphylaxis knowledge, and teaching the steps required for adrenaline auto-injector device administration. We also hypothesized that both programs would be superior to no training.

DESIGN

This controlled, interrupted time-series study was conducted in Australia between August 2011 and April 2013. The University of Western Australia Human Research Ethics Committee gave ethics approval for the study in July 2011.

Intervention participants were eligible if they were pharmacists or pharmacy students within Australia. Pharmacists included professionals registered with the Pharmacy Board of Australia (PBA) and pharmacy interns who held provisional registration as a pharmacist with PBA and who were completing practice hours under the direct supervision of a registered pharmacist. Pharmacy students were individuals enrolled in an approved course of study in the field of pharmacy at an Australian university. Control participants were students of medicine or pharmacy at the University of Western Australia.

All participants were recruited using a convenience approach. E-learning participants were recruited from across Australia while registering online for ASCIA anaphylaxis e-learning between September 2011 and May 2012. Lecture participants were recruited while attending ASCIA anaphylaxis lectures in Perth, Western Australia, between August and September 2011. As the e-learning and lecture participants were separated by both place and time, randomization to either intervention arm was not possible. Control participants were recruited while attending regular university lectures and tutorials in Perth, Western Australia, in September 2012. The aims, objectives, relevance of the study, and option to participate were explained, and all participants provided written, informed consent prior to enrollment in the study (e-learning participants gave consent by selecting an “I Agree” checkbox online). Participants also completed a short demographic survey, which included the variables gender, age group, main job in pharmacy, type of control student, postal code of main workplace, and graduation year.

ASCIA Anaphylaxis Training for Pharmacists

The training program was developed by ASCIA in consultation with the Pharmaceutical Society of Western Australia, the Pharmaceutical Society of Australia, the Pharmacy Guild of Australia, and the Society of Hospital Pharmacists of Australia. The training was advertised as an accredited continuing professional development (CPD) activity with these organizations, as well as through professional newsletters, magazines, and websites. Table 1 provides an overview of the training. Briefly, e-learning and face-to-face lecture programs consisted of the same 4 modules, each designed to take 15 minutes to complete. E-learning was presented as a series of slides using Metamorphosis software (Easy Authoring, Sydney, Australia). Face-to-face lectures were delivered as Microsoft PowerPoint slides.

E-learning participants were allowed to complete training at their own pace, although it was recommended that all modules and tests be completed within a 2-week period. Explanatory notes for slides accompanied the e-learning program to ensure equivalence with spoken material presented in face-to-face lectures. Participants were encouraged to obtain their own trainer adrenaline auto-injector devices and practice the steps required for their administration while completing the program.

Lecture participants attended one of three 1-hour, face-to-face lectures. To ensure consistency across lectures, a dedicated ASCIA-approved lecturer (a clinical immunology/allergy medical specialist) delivered all lectures in the study. Participants were provided with trainer adrenaline auto-injector devices for the duration of the lecture only, and a hands-on activity was included to demonstrate the steps required for administration.
Table 1. An Overview of ASCIA Anaphylaxis Training for Pharmacists

Aim
To provide ready access to accurate and consistent anaphylaxis education to pharmacists throughout Australia and New Zealand.

Learning objectives
On completion of this program participants should be able to:
- Define anaphylaxis.
- Identify common causes of anaphylaxis.
- Identify the signs and symptoms of a mild to moderate allergic reaction.
- Identify the signs and symptoms of anaphylaxis.
- Outline the acute management for anaphylaxis.
- Describe the effects of adrenaline on the body.
- List the side effects of adrenaline.
- Explain how to correctly store adrenaline auto-injector devices.
- Differentiate between the EpiPen and Anapen devices.
- Differentiate between junior and adult adrenaline auto-injector devices.
- Demonstrate how to use the EpiPen and Anapen auto-injectors using trainer devices.
- Outline management required after an adrenaline auto-injector has been administered.
- Explain the purpose of the ASCIA Action Plan.
- Identify the most appropriate Action Plan for the patient.
- Identify the roles of the pharmacist in anaphylaxis management.

Program Content
Module 1 What is allergy and anaphylaxis?
Module 2 Acute management of anaphylaxis
Module 3 Adrenaline auto-injectors
Module 4 ASCIA Action Plans and the role of pharmacists in anaphylaxis management
Module 5 Assessment

Program Delivery
E-learning or face-to-face lectures
15 minutes per module (total of 60 minutes of training, plus assessment)

Assessment
Twelve knowledge assessment questions – multiple choice, yes/no, and order-the-steps questions.

Abbreviations: ASCIA = Australasian Society of Clinical Allergy and Immunology

Completion of a posttest was a requirement for CPD credits in both programs. Understanding the correct answer is considered part of the learning experience, and e-learning participants received feedback from day one of the learning program on their test results, including the correct answers to questions. Lecture participants were able to access the correct answers from researchers in the lecture room after completing the posttest. Neither group received a link to or copy of the test answers, nor were answers provided at the 3-month or 7-month follow-up tests. For students, the training did not form part of any university assessment.

Control participants attended a lecture on women’s health, participated in a discussion session on professional pharmacy practice, or completed a pharmacy dispensing laboratory session. All control interventions lasted 60 minutes.

**EVALUATION AND ASSESSMENT**
Knowledge gain was assessed using a 12-question test, the Anaphylaxis Training Pharmacist Assessment Tool (AT-PaST), which we developed and validated prior to use in the study. We used a combination of multiple-choice, yes/no, and order-the-steps questions to measure knowledge of the prevention, identification, and management of anaphylaxis in the community setting. An expert group of 10 allergy and immunology physicians and 2 clinical pharmacists developed test questions and assessed content validity. Modifications to wording and content changes were made to 2 questions. Face validity was evaluated in a group of 15 pharmacists and 5 pharmacy students, and all agreed they understood the questions and response options. This test was pilot tested on a group of 67 pharmacists who attended an ASCIA anaphylaxis lecture in Adelaide, South Australia, in July 2011. Although the test demonstrated a significant improvement in knowledge scores after the lecture (8.2-11.2 points, paired t test; p<0.001), 4 questions did not show response change and thus may have overstated knowledge (McNemar test; p=0.5). These questions were redeveloped, reviewed by the expert group and pharmacists.
for content and face validity, and incorporated into the final version of the AT-PaST.

The test was administered immediately before training and immediately after training, then 3 and 7 months after training. To reduce practice effect, the questions and their response options were reordered on each test. Participants in the e-learning group completed the pretest and posttest online as part of the e-learning program. Participants in the lecture and control groups completed the pretest and posttest on paper in the lecture or tutorial room. Pharmacy students completed the 3-month follow-up test on paper. All other tests were completed through the online research suite Qualtrics (Qualtrics, Utah). When follow-up tests were due, participants received an e-mail notification and up to 5 e-mail reminders. The follow-up tests remained accessible for 2 weeks. Three prizes (cinema tickets or retail vouchers), with a maximum value of AU$100, were provided as an incentive to complete each of the follow-up tests. Of the participants who completed the 3-month and 7-month follow-up tests, 1 winner from each group (e-learning, lecture or control), was drawn at random. There were no other incentives provided in the study.

As there were no reliable estimates for expected standard deviation in score, we did not conduct a priori sample-size calculations. However, a post hoc power calculation, using the 7-month posttest sample size of 30 in the e-learning group and 50 controls with an observed standard deviation of 1.4 points, showed that the study had 86% power to detect a difference in score of 1 point between groups at the 5% level of significance. Calculations for all other sample sizes in the study groups yielded power estimates between 86% and 100% for between-group and within-group comparisons.\(^3\)

**Analysis**

All analyses were performed using SPSS version 21 (IBM, New York), and reported as 2-sided \( p \)-values with a 5% level of significance. A linear mixed-effects model with post hoc pairwise analysis was used to evaluate changes in short-term and long-term knowledge within and between learning and control groups. We specified score as the dependent variable, with group (e-learning, lecture pharmacists, lecture pharmacy students, or control) and test (pretest, posttest, 3-month and 7-month tests) as covariates. We compared models with and without demographic covariates (gender, age group, main job in pharmacy, type of control student, postal code of main workplace, and years since graduation). As the majority of the sample was from Western Australia, we converted the postal code of main workplace to 2 geographic areas, Western Australia or all other Australian states. Analyses were restricted to participants who had valid, non-missing data for all variables in the model.

We compared the proportion of participants within and between learning groups who, at each test, achieved the minimum standard for anaphylaxis knowledge (score \( \geq 9 \) out of 12) and correctly ordered the steps for EpiPen and Anapen device administration. The Pearson chi-square test was used for between-group comparisons and the McNemar test was used for within-group comparisons. Data for individual answers to the device-ordering questions for the e-learning group were not available for the pretest and posttest (only the overall scores were available). Therefore, we could only make comparisons between the 3-month and 7-month tests in the e-learning group.

**Results**

We recruited 383 participants (277 intervention and 106 controls) to the study (Table 2). There was significant diversity across all 4 groups based on demographic variables \( (p < 0.001)\). E-learning and lecture pharmacists groups were similar by age group and years since graduation, but differed by gender, main job in pharmacy, and location of main job (Table 2). Completion rates across the 4 tests ranged from 100% at posttest, to 47.2% at 7 months (Figure 1), and were similar between groups \( (p = 0.91 \text{ at 7 months})\).

Mean knowledge scores were significantly different by group and test \( (p < 0.001)\), Table 3. With all demographic variables in the model, there were no significant differences in score by age group \( (p = 0.28)\), main job in pharmacy \( (p = 0.06)\), type of control student \( (p = 0.082)\), state of main workplace \( (p = 0.96)\), or years since graduation \( (p = 0.36)\). Score initially differed significantly by gender \( (p = 0.02)\); however, this effect was lost when non-significant variables were removed from the model \( (p = 0.06)\).

Figure 2 and Table 3 show mean AT-PaST scores by group and test. There was a significant and sustained improvement in anaphylaxis knowledge after training in all learning groups (paired \( t \) tests, \( p < 0.001 \) for all comparisons). Mean scores improved by 3.3, 2.8, and 4.6 points immediately after training in the e-learning, lecture pharmacists, and lecture pharmacy students groups, respectively, but decreased in the control group. Mean scores decreased significantly from posttest scores in all learning groups at the 3-month test (a respective score decrease of 1.6, 1.4, 1.7 points). At 7 months, mean scores improved and were above the minimum standard in all learning groups. There were no

Table 2. Participant Characteristics by Intervention and Control Group at Pretest (count and %)

<table>
<thead>
<tr>
<th>Characteristica</th>
<th>E-learning n=57</th>
<th>Lecture Pharmacist n=154</th>
<th>Lecture Pharmacy Students n=66</th>
<th>Control n=106</th>
<th>Total n=383</th>
<th>p&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
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<td>43 (75.4)</td>
<td>41 (26.6)</td>
<td>22 (33.3)</td>
<td>36 (34.0)</td>
<td>142 (37.1)</td>
</tr>
<tr>
<td>Age group (years)</td>
<td>18-24</td>
<td>7 (12.3)</td>
<td>32 (20.8)</td>
<td>37 (56.0)</td>
<td>82 (77.4)</td>
<td>158 (41.2)</td>
</tr>
<tr>
<td></td>
<td>25-34</td>
<td>24 (42.1)</td>
<td>51 (33.1)</td>
<td>23 (34.8)</td>
<td>18 (17.0)</td>
<td>116 (30.3)</td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>9 (15.8)</td>
<td>23 (14.9)</td>
<td>4 (6.1)</td>
<td>0 (0.9)</td>
<td>37 (9.7)</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
<td>11 (19.3)</td>
<td>19 (12.3)</td>
<td>1 (1.5)</td>
<td>0</td>
<td>31 (8.1)</td>
</tr>
<tr>
<td></td>
<td>55+</td>
<td>6 (10.5)</td>
<td>27 (17.5)</td>
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<td>33 (8.6)</td>
</tr>
<tr>
<td>Main job in pharmacy&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Community pharmacist</td>
<td>27 (47.3)</td>
<td>99 (64.3)</td>
<td>NA</td>
<td>NA</td>
<td>126 (32.9)</td>
</tr>
<tr>
<td></td>
<td>Hospital pharmacist</td>
<td>16 (28.0)</td>
<td>15 (9.7)</td>
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<td>NA</td>
<td>31 (8.1)</td>
</tr>
<tr>
<td></td>
<td>Pharmacy intern</td>
<td>4 (7.0)</td>
<td>22 (14.3)</td>
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<td>NA</td>
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<td>Type of control</td>
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<td>66 (17.2)</td>
</tr>
<tr>
<td></td>
<td>Pharmacy student</td>
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<td>NA</td>
<td>NA</td>
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<td>35 (9.1)</td>
</tr>
<tr>
<td>Years since graduation&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Not graduated</td>
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<td>0</td>
<td>65 (98.5)</td>
<td>101 (95.2)</td>
<td>166 (43.3)</td>
</tr>
<tr>
<td></td>
<td>Less than 5</td>
<td>8 (14.0)</td>
<td>44 (29.5)</td>
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<td>0</td>
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</tr>
<tr>
<td></td>
<td>5-10</td>
<td>17 (29.8)</td>
<td>33 (22.1)</td>
<td>0</td>
<td>0</td>
<td>50 (13.0)</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>9 (15.8)</td>
<td>13 (8.7)</td>
<td>0</td>
<td>0</td>
<td>22 (5.7)</td>
</tr>
<tr>
<td></td>
<td>More than 15</td>
<td>23 (40.4)</td>
<td>59 (39.6)</td>
<td>0</td>
<td>0</td>
<td>82 (21.4)</td>
</tr>
<tr>
<td>Location of main job</td>
<td>Western Australia</td>
<td>9</td>
<td>154 (100)</td>
<td>65 (98.5)</td>
<td>101 (95.2)</td>
<td>329 (85.9)</td>
</tr>
<tr>
<td></td>
<td>New South Wales</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14 (3.6)</td>
</tr>
<tr>
<td></td>
<td>Victoria</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13 (3.4)</td>
</tr>
<tr>
<td></td>
<td>Queensland</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12 (3.1)</td>
</tr>
<tr>
<td></td>
<td>South Australia</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4 (1.0)</td>
</tr>
<tr>
<td></td>
<td>Tasmania</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<td></td>
<td>Australian Capital Territory</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>2 (&lt;1)</td>
</tr>
<tr>
<td></td>
<td>Northern Territory</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td>Main job by region</td>
<td>Western Australia</td>
<td>9 (15.8)</td>
<td>154 (100)</td>
<td>65 (98.5)</td>
<td>101 (95.2)</td>
<td>329 (85.9)</td>
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<tr>
<td></td>
<td>Rest of Australia</td>
<td>48 (84.2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>48 (12.5)</td>
</tr>
</tbody>
</table>

a Eight participants (2 lecture pharmacists, 1 lecture pharmacy student and 5 controls) did not provide any demographic data.

b Pearson chi-square p value for comparison of demographic variables across all 4 groups. Location of main job was compared by region only.

p Values for comparison of demographic variables between e-learning and lecture pharmacists groups were: gender: p<0.001; age group: p=0.11; main job: p<0.001; years since graduation: p=0.08; main job by region: p>0.001.

c Of those completing the demographic questionnaire, 7 lecture group pharmacists did not answer the main job question.

d Of those completing the demographic questionnaire, 4 e-learning participants stated ‘other main job’ including defence force, industrial, and compounding pharmacist jobs.

3 lecture group pharmacists did not answer the years since graduation question.

NA: not applicable

significant changes in mean score in the control group after posttest.

Figure 3 shows the change in mean AT-PaST scores by group over time. All learning groups performed significantly better on all posttests compared to control (p<0.001 for all comparisons). E-learning and lecture pharmacist participants had similar scores across all tests except posttest, where e-learning scores were slightly
higher (0.65 points, p=0.04). Lecture pharmacy students had the greatest gains in knowledge of all learning groups, yet lower scores. It was not possible to compare e-learning scores for pharmacy students with lecture pharmacy students’ scores, as only 3 pharmacy students completed the e-learning program.

There were significant and sustained improvements in the proportion of learners achieving the minimum standard for anaphylaxis knowledge after training (Table 4). Less than 40% of e-learning and lecture pharmacists achieved the minimum standard before training; however, 7 months after training, over 80% achieved this standard. The improvement in the proportion of lecture pharmacy students achieving the standard was almost tenfold: from 6.7% pretest to 61.8% at 7 months.

Although there were sizeable gains in the proportion of lecture participants who passed the decision-making questions after training, these gains were not sustained over time (Table 4). At 7 months, 63.3% of e-learning participants and 61.5% of lecture pharmacists correctly ordered the 4 steps for both EpiPen and Anapen, an improvement of around 15% in each group from pretest.

**DISCUSSION**

Pharmacists play a vital role in the management of anaphylaxis patients. Easily accessible, effective anaphylaxis education is essential to fulfill this role. However, there is little evidence of the effectiveness of anaphylaxis training for pharmacists. We evaluated the e-learning program, ASCIA Anaphylaxis e-training for pharmacists, and measured its effectiveness in terms of knowledge change.

This education program was associated with significant and sustained improvements in anaphylaxis knowledge. Short-term knowledge gains (on average, a 39% improvement in mean score) were similar to immediate gains seen in other pharmacy e-learning effectiveness studies. Persistence of knowledge 7 months after training was high: almost 90% of e-learners achieved at or above our minimum standard for anaphylaxis knowledge, compared to 45% of the same learners before training. Thus, the results add long-term effectiveness to the existing body of e-learning pedagogical research and more importantly, demonstrate that this education program is effective long-term. ASCIA Anaphylaxis e-training for pharmacists was as effective as lecture training,
and significantly more effective than no training, at improving short-term and long-term anaphylaxis knowledge in pharmacists. We were unable to demonstrate effectiveness of this e-learning program in pharmacy students due to low numbers of student participants. Even so, lecture training was effective at improving short-term and long-term anaphylaxis knowledge in pharmacy students, and other research has demonstrated short-term effectiveness of e-learning in pharmacy students in different subject areas. Therefore, it is likely that this e-learning program would also be effective for pharmacy students. There was no change in anaphylaxis knowledge in those who did not receive training. This is consistent with the broader literature for short-term e-learning effectiveness. However, as far as we know, this is the first study to demonstrate long-term differences in an e-learning group compared to a group who did not receive training.

An essential part of anaphylaxis education for patients is hands-on training in the use of adrenaline auto-injectors. Although pharmacists are ideally placed to deliver this training, there is evidence that the majority of anaphylaxis patients do not receive it. People who do not know how or when to use their adrenaline auto-injector may elect not to do so in an emergency, or may incorrectly activate the device. Devices and procedures change over time, and there is a constant need to improve pharmacists’ skills in this area, so they can better train those at risk of anaphylaxis. Approximately two-thirds of e-learners in our study were able to correctly order all of the steps required for both EpiPen and Anapen administration 7 months after training. Lecture participants achieved results similar to those for e-learners, even though they had hands-on practice with devices during training. Although long-term device recall was poorer compared to anaphylaxis knowledge, other research has shown device recall may wane over time. In a group of physician trainees, only one-third accurately demonstrated devices 6 months after training. In our study, the complexities of the different devices, lack of regular experience with them, and the fact they were new to many pharmacists at the time of training may have impacted pharmacists’ long-term recall. As the participants were geographically diverse, we did not evaluate device demonstration as a skill. Thus, while knowledge of device administration steps improved at 7 months, application of this knowledge was not assessed.

**Strengths and limitations**

This study has a number of strengths. The training program and assessment test were developed using a rigorous approach and validated prior to use. We included 2 comparator groups in our study: traditional lecture training and no training. Further, we conducted 3 posttraining tests, with a follow-up period considerably longer than that of other e-learning effectiveness studies. Retention rates were high: almost all participants completed the posttest, and around 50% completed all 4 tests. This compares favorably with response rates to e-mailed surveys (where the average response rate is 33%). The study had sufficient power to detect a mean score difference of at least 1 point within and between groups. Finally, there was no duplication in recruitment of pharmacists to intervention groups (pharmacists who participated in the e-learning group could not participate in the lecture group and vice versa).

However, we did not randomize participants to intervention or control groups, and as we adopted a convenience method of recruitment, the study may have been affected by selection bias. The lack of randomization would only affect between-group comparisons. Nevertheless, generalization of the e-learning results may be limited to people with a high comfort level with learning via the Internet and/or who have experience using multimedia online. Given that the study sample represented well-educated professionals who had daily exposure to...
Internet-related technologies, we expected knowledge and use of the Internet to be high in this population. Lecture participants also were required to show a high level of comfort with Internet use, as they were required to complete all follow-up tests online. Further, the vast literature evaluating e-learning programs, the increasing delivery of online education, a historical early acceptance of technology in the pharmacy profession (all suggesting pharmacists are confident Internet users), and the difficulties achieving a true random sample in online research may have combined to reduce the effect of selection bias in our study.  

In addition, we evaluated ASCIA Anaphylaxis e-training for pharmacists in a context where learners now define their education strategies (eg, choosing rather than being recruited to undertake this program), which may have provided real-world evidence for effectiveness.

The control group did not include pharmacists and began the study at a different time than the intervention groups. We chose to use students as controls because we could ensure that they did not receive inadvertent exposure to anaphylaxis training and thus contamination during follow up. Nonetheless, we acknowledge that control scores were significantly lower than intervention scores at pretest. This ultimately impacted pairwise comparisons and may have distorted the magnitude of the difference between training and no training. Moreover, the control scores did not change over time, despite participants completing the same test questions on 4 occasions. This may have been because of the result of lack of interest in the topic, lack of perceived relevance to practice, fatigue from completing multiple tests, or a true effect.

We used the same 12 questions for each of the 4 tests. There was the potential for a learning effect from the test itself, although we did attempt to control for practice effect, and it was unlikely given there was no change in control scores. Although we did not adjust for multiple comparisons in the analyses, we do not consider this to be a limitation. The key effectiveness measure—long-term knowledge change—was assessed in 3 post hoc tests (e-learning, lecture training, or no training groups, comparing 7-month tests and pretests), and the magnitude of the change in knowledge at all tests was large. Therefore, with low numbers of multiple comparisons, an effect size of practical relevance, and very low p-values (\(p < 0.001\)), there was no need for adjustment.

Finally, we acknowledge that this training may not have been wholly responsible for knowledge demonstrated at 7 months. There is the potential for academic dishonesty with tests completed remotely. However, participants were de-identified and study incentives were not dependent on scores, so we consider the motivation to deceive was low. Although exposure to alternate anaphylaxis information over time (eg, through general media or through self-study) may have confounded the results, knowledge gain across learner groups was consistent (with no gain in the control group) over 7 months.

Implications and recommendations

ASCIA Anaphylaxis e-training for pharmacists is part of a group of e-learning packages available to pharmacists and other health professionals, school and childcare workers, and the general community throughout Australia and New Zealand. Since 2011, more than 760 pharmacists, 4600 health professionals, 130 000 school and childcare workers, and 1100 members of the general public, have completed this training. The key messages in each of these programs are equivalent, and the language used in each program is appropriate for the intended
Investigating the Management of Anaphylaxis in Pharmacy

### Table 4. Learners Achieving the Minimum Standard for Anaphylaxis Knowledge and the Correct Device Administration Steps by Group and Test.

<table>
<thead>
<tr>
<th></th>
<th>E-learning</th>
<th>Lecture Pharmacists</th>
<th>Lecture Pharmacy Students</th>
<th>( p ) all groups ( ^a )</th>
<th>Lecture Pharmacists ( ^b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion achieving minimum standard, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>45.1</td>
<td>45.8</td>
<td>6.7</td>
<td>&lt;0.001</td>
<td>0.94</td>
</tr>
<tr>
<td>Posttest</td>
<td>96.2</td>
<td>97.4</td>
<td>85.5</td>
<td>0.002</td>
<td>0.66</td>
</tr>
<tr>
<td>3-month</td>
<td>85.0</td>
<td>74.2</td>
<td>53.3</td>
<td>0.004</td>
<td>0.17</td>
</tr>
<tr>
<td>7-month</td>
<td>86.7</td>
<td>80.8</td>
<td>61.8</td>
<td>0.03</td>
<td>0.47</td>
</tr>
<tr>
<td>( \rho )</td>
<td>0.021</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Proportion correctly ordering device administration steps, %

|                      |            |                     |                           |                            |                             |
| Pretest              | -          | 34.0                | 28.3                      | 0.43                       | -                           |
| Posttest             | -          | 87.4                | 77.4                      | 0.07                       | -                           |
| 3-month              | 45.0       | 47.2                | 40.0                      | 0.73                       | 0.82                        |
| 7-month              | 63.3       | 61.5                | 59.0                      | 0.45                       | 0.86                        |
| \( \rho \)          | -          | 0.002               | 0.086                     |                            |                             |

\( ^a \) Pearson chi-square test for difference in proportions across all learning groups at each test.

\( ^b \) McNemar test for difference in proportions between the 7-month test and pretest for each group.

Proportion achieving minimum standard - percentage of participants completing the test who achieved a score \( \geq9 \) out of 12.

Proportion correctly ordering device administration steps - percentage of participants completing the test who correctly ordered all 4 steps required for both EpiPen and Anapen device administration.

NA - data were not available for this group and these tests.

Anaphylaxis e-training programs have not previously been evaluated for effectiveness. The study demonstrates that ASCIA Anaphylaxis e-training for pharmacists is effective at increasing and maintaining long-term anaphylaxis knowledge across a demographically and geographically diverse population of pharmacists.

Because accurate and current anaphylaxis knowledge is an essential part of anaphylaxis management, the question of when to retrain should be considered. As the majority of e-learners met the minimum standard for anaphylaxis knowledge 7 months after training, it is difficult to define a retraining interval based on declining knowledge. An additional follow-up evaluation of the same participants at 18-24 months may be a realistic timeframe. For pharmacy students in the era of the flipped classroom, the addition of this e-learning program would increase their anaphylaxis knowledge while allowing them to actively practice with adrenaline auto-injector devices. Investigating the effectiveness of the e-learning program in this context would be useful.

Pharmacists have been identified as an underutilized resource for providing anaphylaxis education and device training at the time of adrenaline auto-injector supply.\(^{13,44}\) One-third of e-learners in the study did not correctly order the steps for EpiPen and Anapen device administration, and this may impact the quality of advice provided with these devices. Covert or overt simulation-based research is required to determine what happens at the time of adrenaline auto-injector distribution in pharmacies, as a measure of translation of anaphylaxis learning to practice. Research options include simulated patient methodology to assess device demonstration and anaphylaxis knowledge, or the use of overt simulation (for example, using mannequins) to investigate the pharmacist's response to anaphylaxis.

**SUMMARY**

Regular education updates are required for pharmacists to maintain current knowledge about the prevention and treatment of anaphylaxis and how to supply and use adrenaline auto-injectors. ASCIA Anaphylaxis e-training for pharmacists increased anaphylaxis knowledge long-term. Knowledge gains were similar to ASCIA lecture training and superior to no training. This e-learning program offers a convenient, effective, no-cost option for pharmacists to improve and maintain their anaphylaxis knowledge. Future evaluations should seek to define an interval for retraining and investigate translation of anaphylaxis knowledge to practice.
ACKNOWLEDGMENTS

The authors acknowledge the Australasian Society of Clinical Immunology and Allergy (ASCIA) for creating and delivering anaphylaxis education to all members of the community and for enabling us to evaluate the effectiveness of their anaphylaxis training for pharmacists. The authors thank Ms. Suzanne Grainger for technical support and for providing the data collection forms for pretests and posttests for the e-learning participants, and Ms. Laura Firth, Department of Mathematics and Statistics, The University of Western Australia, for her assistance with planning the statistical analyses.

The first author, Ms. Sandra Salter, was the recipient of a University Postgraduate Award and UWA Top-Up Scholarship, provided by The University of Western Australia.

REFERENCES


4.3 Key points from this chapter

- Before training, most pharmacists had limited anaphylaxis knowledge. Less than half achieved the minimum standard for anaphylaxis knowledge at this point.

- Knowledge of adrenaline autoinjector technique was also poor. Before training only one-third of pharmacists could correctly order the steps for adrenaline autoinjector administration.

- ASCIA anaphylaxis training for pharmacists effected immediate and long-term gains in anaphylaxis knowledge. Immediately after training, almost 100% of pharmacists achieved the minimum standard for anaphylaxis knowledge and despite some decline in knowledge over time, by 7 months more than 80% of pharmacists still achieved the minimum standard. There were similar improvements in adrenaline autoinjector technique immediately after training, although by 7 months, only 61-63% of pharmacists correctly ordered the steps for autoinjector administration, a significant decline.

- Participants who did not receive anaphylaxis training (controls), showed no change in anaphylaxis knowledge immediately or long-term after the control intervention. Whether pharmacists engaged in anaphylaxis e-learning or lecture training did not affect knowledge scores.
4.4 Bibliography


Chapter 5

Pharmacists’ Response to Anaphylaxis in the Community: Advice Provided to Patients in the Pharmacy

Presented as published in BMJ Open.


5.1 Background

Chapter 4 of this thesis demonstrated that significant long-term improvements in pharmacists’ knowledge of anaphylaxis and adrenaline autoinjector technique could be achieved after appropriate training. Both ASCIA e-learning and face-to-face anaphylaxis training programs provide immediate and sustained knowledge gains in the majority of pharmacists. This improved knowledge may translate to improved patient care and ultimately reduce anaphylaxis morbidity and mortality in the community.

However, there is no evidence among pharmacists for translation of anaphylaxis knowledge to practice. Pharmacists must prepare the person at risk of anaphylaxis to self-manage their condition, and the best opportunity to do this is during adrenaline autoinjector supply. In addition, pharmacists must themselves be prepared to manage any patients who present to the pharmacy for assistance during acute anaphylaxis. Therefore, beyond knowledge assessments, practice-based evidence is required for anaphylaxis preparedness in Australian community pharmacists.
This chapter aims to address the third set of research questions by assessing the advice provided by the pharmacist to an anaphylaxis patient during a pharmacy consultation. This study considers the elements of knowledge that are essential for anaphylaxis preparedness, and if pharmacists apply that knowledge as advice to patients under usual conditions of practice.
5.2 Publication

**BMJ Open** Pharmacists’ response to anaphylaxis in the community (PRAC): a randomised, simulated patient study of pharmacist practice

Sandra M Salter,1 Brock Delfante,1 Sarah de Klerk,1 Frank M Sanfilippo,2 Rhonda M Clifford1

**ABSTRACT**

**Objective:** To evaluate how community pharmacists manage patients with anaphylaxis.

**Design:** A randomised, cross-sectional, simulated patient study of community pharmacist practice.

**Setting:** 300 metropolitan pharmacies located in Perth, Australia, randomised to three groups of 100 pharmacies. Each group corresponded to a different epinephrine autoinjector: original Epipen, new look Epipen or Anapen.

**Participants:** 800 pharmacies were visited with 271 simulated patient visits included in the final analysis (88-original Epipen, 92-new look Epipen, 91-Anapen).

**Outcome measures:** Primary anaphylaxis preparedness (readiness to treat acute anaphylaxis). Secondary anaphylaxis engagement (willingness to engage the patient in a discussion about their anaphylaxis).

**Methods:** Simulated patients approached pharmacists, using a standardised scenario, for assistance with epinephrine autoinjector use and advice about the use of antihistamines in anaphylaxis. Scores for each outcome were obtained based on the number of predefined statements addressed by the pharmacist during the consultation (maximum score=5 for preparedness and 8 for engagement).

**Results:** The mean anaphylaxis preparedness score was 2.99 points (SD 1.17). Scores for new look Epipen were significantly higher than for original Epipen and Anapen (2.75 vs 2.38 points, p=0.027; 2.75 vs 2.03 points, p=0.011, respectively). Overall, 17.3% of pharmacists correctly demonstrated the epinephrine autoinjector. The mean anaphylaxis engagement score was 3.11 points (SD 1.73). Scores for new look Epipen were similar to original Epipen and Anapen (3.11 vs 3.32 points; 3.11 vs 2.99 points, both p=0.42). Engagement was associated with preparedness. For each additional engagement point, preparedness increased by 7% (0.357 points; 95% CI 0.291 to 0.424; p<0.001).

**Conclusions:** Pharmacists demonstrated reasonable knowledge of anaphylaxis symptoms and emergency care, but had poor epinephrine autoinjector technique and rarely discussed anaphylaxis action plans. Pharmacists who had a more comprehensive discussion about anaphylaxis with patients, were more prepared for anaphylaxis emergencies. Future research should evaluate the nature and significance of errors in pharmacists’ autoinjector technique.

**Strengths and limitations of this study**

- This is the first study to consider pharmacists’ management of anaphylaxis, in terms of readiness to treat acute anaphylaxis, and the impact of various factors on such readiness (including willingness to comprehensively discuss anaphylaxis with patients).

Simulated patient methodology, with rigorous tool development, training, evaluation and pilot testing prior to the study was successfully employed to measure true pharmacist practice. There was a risk of recall bias in data collection (which could underestimate real behaviour by 10–20%), however this was minimised by capping the number of simulated patient visits per day, and requiring immediate data collation after each visit.

Outcome measures were defined based on national and international pharmacy practice and anaphylaxis guidelines, however we did not assess whether the pharmacist advised the patient to lay flat. Although this may have distorted true anaphylaxis preparedness, we did not assess this point because of the dissimilarity between the scenario and a real anaphylaxis emergency.

**INTRODUCTION**

Anaphylaxis is a severe, progressive allergic reaction that is rapid in onset and might cause death.1 The lifetime prevalence of anaphylaxis in developed countries has been estimated at 1–2%.2–5 However, it is difficult to accurately quantify anaphylaxis diagnosis is based on clinical judgement and may at times be missed; coding in hospitals and prehospital emergency services is inconsistent;
and no standard mechanism exists for reporting new cases of anaphylaxis. Further, patients may misinterpret symptoms of anaphylaxis and up to 50% may not seek emergency treatment during or after initial events.\textsuperscript{1,7-11}

Nonetheless, anaphylaxis rates in Australia are increasing, in line with worldwide trends.\textsuperscript{7,10} Between 1993–1994 and 2004–2005, anaphylaxis hospitalisations in Australia increased from 3.7 to 10.8/100,000 population; an average annual increase of 8.8%.\textsuperscript{15} Much of this increase is attributed to food-induced anaphylaxis—the most common cause of anaphylaxis in the community setting (and responsible for 30% of all fatal anaphylaxis cases).\textsuperscript{1,5,13} Notably, Australia has the highest rate of food allergy in the world, with challenge-proven prevalence of more than 10% in young children.\textsuperscript{16,17}

Treatment of anaphylaxis requires prompt administration of epinephrine. Delayed epinephrine is associated with more severe reactions and fatal anaphylaxis.\textsuperscript{1,10} Epinephrine autoinjector devices are often prescribed for patients with a history of anaphylaxis to allow early self-management of recurrent events, yet the majority of patients do not understand how or when to use them.\textsuperscript{1,9} A survey of 1885 patients who had experienced anaphylaxis found 79% did not use epinephrine, and in this group 28% had not previously received a prescription for epinephrine.\textsuperscript{9}

Therefore, considering (1) the complexities of diagnosis and variations in signs and symptoms of anaphylaxis; (2) the uncertain yet increasing burden of disease; (3) the need for urgent epinephrine during anaphylaxis and (4) the likelihood for people to be unprepared for anaphylaxis in the community, the options for management of acute anaphylaxis in this setting warrant consideration. Patients may attend hospitals, call emergency services, try a medical practitioner or self-manage. However, there is increasing anecdotal evidence that some patients choose to attend their local pharmacy instead. This may be because patients or carers do not recognise the symptoms, or understand the treatment of anaphylaxis and instead seek (erroneously) to purchase antihistamines from their pharmacist. Those who do identify the need for immediate treatment may choose the pharmacist for reasons of urgent accessibility, familiarity, convenience and awareness that pharmacies stock epinephrine autoinjectors.

While there is good evidence for the roles of the patient, medical practitioner, emergency services and hospital personnel in the management of anaphylaxis,\textsuperscript{20-22} evidence for the role of the community pharmacist is scarce. Surveys of opinions about treating anaphylaxis, and epinephrine autoinjector technique exist,\textsuperscript{25-27} but there is no research evaluating pharmacist practice or preparedness for anaphylaxis emergencies. We believe that patients will increasingly seek out pharmacists for anaphylaxis first aid. Given the unpredictable nature of anaphylaxis, the dramatic rise in food-induced anaphylaxis, the potential for first-time reactions to be fatal,\textsuperscript{28} and the accessibility of pharmacists as a treatment destination, there is an urgent need to identify if pharmacists are ready to manage anaphylaxis. An important duality in anaphylaxis management must be considered—first providing first aid when required, and second engaging the non-acute patient in discussion so they may be prepared for future events. The purpose of this study of Australian community pharmacist practice was to identify (1) their preparedness for acute anaphylaxis; (2) factors that impact on such preparedness and (3) willingness to engage the patient in a discussion about anaphylaxis.

METHODS

We conducted a randomised, cross-sectional, simulated patient study of pharmacist practice in Perth, Australia from April to May 2012.

Setting and recruitment

All Perth metropolitan pharmacies located within a 20 km radius of the Perth Central Business District, and listed on the Pharmacy Registration Board of Western Australia Premises Register\textsuperscript{29} were included in the sampling frame (n=334). A random sample of 300 pharmacies was selected using a random numbers generator,\textsuperscript{30} and then further randomised into three groups of 100 pharmacies. Each pharmacy was visited once by one of three researchers, who enacted a standardised simulated patient scenario, designed to build a profile of a patient who had recently experienced anaphylaxis for the first time.

Exclusions

Hospital dispensaries and compounding pharmacies were excluded as they may not routinely supply epinephrine autoinjectors or be directly accessible by patients. Where the researcher recognised the pharmacist or any other staff member on duty, the visit was abandoned and the pharmacy excluded.

Anaphylaxis management

We considered preparedness for acute anaphylaxis as the primary outcome and willingness to engage the patient in a discussion about their anaphylaxis as a secondary outcome (box 1). As there are no guidelines specific to pharmacist care for patients with anaphylaxis in Australia, we used key statements from the Australasian Society of Clinical Immunology and Allergy (ASCIA) Action Plan for Anaphylaxis\textsuperscript{11} and the World Allergy Organization (WAO) Anaphylaxis Guidelines\textsuperscript{10} to define the primary outcome. We added concepts from Australian Professional Practice Standards,\textsuperscript{31} and National Competency Standards Framework for Pharmacists in Australia\textsuperscript{32} to define the secondary outcome.

Scenario

At each pharmacy, the patient asked to speak with the pharmacist, requested explanation of their epinephrine autoinjector device, and asked about the use of
investigating the management of anaphylaxis in pharmacy

box 1: anaphylaxis management

- Anaphylaxis preparedness (readiness to treat acute anaphylaxis)
- Identify the symptoms of anaphylaxis
- Identify the need for hospital care after administering an epinephrine autoinjection
- Identify the need for an action plan for anaphylaxis
- Correctly demonstrate an epinephrine autoinjection device*  
  * Demonstrate an understanding that antihistamines are ineffective in treating acute anaphylaxis.
- Anaphylaxis engagement (willingness to engage the patient in a discussion about their anaphylaxis)
  - Ask specifically about the allergen that caused anaphylaxis
  - Confirm specialist medical follow-up planned
  - Physically demonstrate the epinephrine autoinjector
  - Provide written material on how to use the epinephrine autoinjector
  - Provide advice about autoinjector storage
  - Check epinephrine autoinjector expiry date
  - Explain the side effects of epinephrine
- General anaphylaxis advice provided without prompting.

Box 2: scenario description

- Scenario
  - The patient was taken by ambulance to hospital a week ago with their first episode of anaphylaxis.
  - They now have two epinephrine autoinjector devices (of the same type) but do not know how or when to use them.
  - The patient is uncertain about what they should do if they have another episode of anaphylaxis.
  - "Hi, could I please speak to the pharmacist?"
  - [Pharmacist attends]. I have recently been given this, [show epinephrine autoinjector], but I don't know how to use it. Could you show me?"
- During the ensuing discussion, the patient asked:
  - "I've also been told I can use antihistamines. What do you think?"
  - Responses were provided (as follows) to questions asked by the pharmacist. No additional information was volunteered. The patient accepted all advice provided by the pharmacist without question.

- Anaphylaxis background
  - Where did you get that? My relative picked it up for me when I came home from the hospital.
  - When did you go to hospital? Last week.
  - Did you have anaphylaxis last week when you went to hospital? Yes that's what the doctor said.
  - What happened? I was having dinner, eating prawns at a friend's house when I started coughing and found it hard to breathe. I got a rash on my face and chest, and the breathing got more and more difficult, so my friends called an ambulance. I spent the night in ED.

- Antihistamine request
  - Who told you that? Someone at the hospital.
  - What were you told to use an antihistamine for? I can't remember but I suppose it's for my allergy.
  - Have you taken an antihistamine before? No.
  - Do you prefer a desalting or non-desalting antihistamine? Whatever you recommend.
  - Any allergies? I think I'm allergic to prawns.
  - Medical conditions? Mild eczema on and off.
  - Have you used anything before for allergy? No.
  - Are you seeing an allergy specialist? Yes, in two weeks' time.
  - Do you have an Action Plan for Anaphylaxis? No.
  - If an antihistamine was offered for sale, the patient agreed and made the purchase.

- Box 2: scenario description

Additional scenario information was provided only when the patient responded to direct pharmacist questions (box 2). At the time of this research, availability of epinephrine autoinjector devices in Australia was changing. Original EpiPen was being replaced by new look EpiPen and AnaPen had been available as an alternative device for less than 2 years. Thus we considered it important to identify if older or newer devices corresponded with better management, and each researcher applied one of these devices in their scenario request. Devices were allocated to researchers randomly. Original EpiPen was allocated to a female Master of Pharmacy student, aged 20–25 years. New look EpiPen was allocated to a male Master of Pharmacy student, aged 20–25 years. AnaPen was allocated to an experienced simulated patient actor (female, aged 40–45 years).

We conducted a full-day training session where simulated patients performed the scenario and, to ensure familiarity, practised device demonstration. Pharmacist questions were anticipated and practised; modifications to patient answers were made to ensure the scenario was memorable for the actor and realistic for the pharmacist. Finally, devices used during the study were replenished as required to ensure they looked ‘new’ for each pharmacy visit.

Data collection

We developed a data collection tool specifically for this study. To aid recall, variables were ordered in sections to present a logical flow for recording that matched the anticipated flow of the scenario. Preparedness variables (broadly: allergy assessment, autoinjector demonstration, antihistamine recommendations) and demographic variables (broadly: pharmacy environment, pharmacist age and gender) were collected (see online supplementary appendix 1). Prior to use, the tool was evaluated for face validity in a group of 10 pharmacists and evaluated for usability in a round-table discussion during the


Investigating the Management of Anaphylaxis in Pharmacy
training session. To reduce the potential for scenario and data collection fatigue, researchers were limited to a maximum of eight pharmacy visits per day, 5 days per week. The tool was completed immediately after each pharmacy visit (away from the premises), and data subsequently entered to a database (Microsoft Excel, Microsoft Corporation, Redmond, USA). During the study, an independent auditor crosschecked a random sample of 30 completed tools against data entered in the database. The proportion of records in disagreement was 0.27%.

Scenario pilot
The final scenario and data collection tool were piloted in a random sample of nine pharmacies (5 per device). The scenario remained unchanged. Minor additions to the tool were made prior to the main study. Pharmacies visited in the pilot were not included in the final analysis.

Analysis
All analyses were performed using SPSS V21 (IBM, New York, USA), and reported as two-sided p values with a 5% level of significance. Descriptive statistics were obtained for demographic and preparedness variables by autoinjector group, and assessed using Pearson χ² test or Fisher's exact test.

Scores for each outcome were obtained based on the number of statements addressed during the consultation (box 1), with ‘anaphylaxis preparedness’ being the score for the primary outcome (maximum = 5), and ‘anaphylaxis engagement’ as the score for the secondary outcome (maximum = 8). One-way analysis of variance with post hoc pairwise analysis was used to evaluate differences in mean preparedness scores by autoinjector group.

Multiple linear regression was performed to identify factors impacting on anaphylaxis preparedness. We specified anaphylaxis preparedness score as the dependent variable. Pharmacy type and location; pharmacist gender, estimated age and how busy they were (as a ratio of total customers in store to total pharmacy staff); time of day the visit was performed; type of autoinjector demonstrated; and anaphylaxis engagement score were covariates. We used a backward automated model selection approach to identify significant factors impacting on anaphylaxis preparedness. We did not include antihistamine sales data in the model because fewer than half of all consultations resulted in a sale. Instead, advice provided with the sale of an antihistamine was analysed descriptively by epinephrine autoinjector group.

As there were no reliable estimates for expected SD in anaphylaxis preparedness score, we did not conduct a priori sample size calculations. However, a post hoc power calculation using the sample sizes of n = 92 (new-looking Epipen) and n = 91 (Anapen), with an observed SD of 1.17 points, showed our study had at least 82% power to detect a difference in anaphylaxis preparedness score of 0.5 points or more between groups at the 5% level of significance.34

RESULTS
We visited all 300 pharmacies randomised to the study, and included 271 (90%) of the visits in the final analysis (figure 1). Descriptive results are reported in table 1. The majority of pharmacists were female (n=158, 52.8%), and estimated to be aged between 20 and 40 years of age (20–30 years: 40.2%, 31–40 years: 32.5%, total n=197, 72.7%).

Anaphylaxis preparedness
The mean anaphylaxis preparedness score was 2.39 (SD=1.17) out of a possible 5 points (n=271). Scores for new-looking Epipen were significantly higher than for original Epipen and Anapen (2.75 vs 2.38 points, p=0.027, 2.75 vs 2.03 points, p=0.001, respectively). Most pharmacists demonstrated an understanding that antihistamines are ineffective in treating anaphylaxis (n=246, 90%), while two-thirds advised the patient to call an ambulance after administering an epinephrine autoinjector (n=165, 60.1%). Although the majority of pharmacists discussed the symptoms of anaphylaxis (n=176, 64.9%), significantly fewer were from the Anapen group (n=37, p=0.001). Few pharmacists correctly demonstrated the epinephrine autoinjector (n=47, 17.3%), or asked whether the patient had an anaphylaxis action plan.

![Figure 1 Participation in the PRAC study.](image-url)
Table 1: Study characteristics by epinephrine autoinjector device group (count and %)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Original EpiPen n=88 (32.5)</th>
<th>New-look EpiPen n=92 (33.9)</th>
<th>Anapen n=91 (33.6)</th>
<th>Total n=271 (100)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacy demographics (n=271)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharmacy type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>44 (50)</td>
<td>47 (51.1)</td>
<td>39 (42.9)</td>
<td>130 (48)</td>
<td>0.05</td>
</tr>
<tr>
<td>Chain</td>
<td>31 (36.2)</td>
<td>40 (43.5)</td>
<td>47 (51.6)</td>
<td>118 (43.5)</td>
<td></td>
</tr>
<tr>
<td>Discount/warehouse</td>
<td>13 (14.8)</td>
<td>5 (5.4)</td>
<td>5 (6.5)</td>
<td>23 (8.5)</td>
<td></td>
</tr>
<tr>
<td>Pharmacy location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street</td>
<td>52 (59.1)</td>
<td>49 (53.3)</td>
<td>30 (33)</td>
<td>131 (48.3)</td>
<td>0.004†</td>
</tr>
<tr>
<td>Medical centre</td>
<td>8 (9.1)</td>
<td>6 (6.5)</td>
<td>13 (14.3)</td>
<td>27 (10)</td>
<td></td>
</tr>
<tr>
<td>Shopping centre</td>
<td>27 (30.7)</td>
<td>37 (40.2)</td>
<td>44 (48.4)</td>
<td>108 (39.9)</td>
<td></td>
</tr>
<tr>
<td>Private hospital outpatient facility</td>
<td>1 (1.1)</td>
<td>0 (0)</td>
<td>4 (4.4)</td>
<td>5 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Pharmacist demographics (n=271)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35 (39.8)</td>
<td>39 (42.4)</td>
<td>39 (42.9)</td>
<td>113 (41.7)</td>
<td>0.90</td>
</tr>
<tr>
<td>Estimated age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.03†</td>
</tr>
<tr>
<td>20-30</td>
<td>36 (40.9)</td>
<td>46 (50)</td>
<td>27 (29.7)</td>
<td>109 (40.2)</td>
<td></td>
</tr>
<tr>
<td>31-40</td>
<td>32 (36.4)</td>
<td>20 (21.7)</td>
<td>30 (33.9)</td>
<td>82 (30.5)</td>
<td></td>
</tr>
<tr>
<td>41-50</td>
<td>11 (12.5)</td>
<td>18 (19.6)</td>
<td>22 (24.2)</td>
<td>51 (18.8)</td>
<td></td>
</tr>
<tr>
<td>51-60</td>
<td>9 (10.2)</td>
<td>7 (7.6)</td>
<td>5 (5.5)</td>
<td>21 (7.7)</td>
<td></td>
</tr>
<tr>
<td>60+</td>
<td>0 (0)</td>
<td>1 (0.4)</td>
<td>1 (0.4)</td>
<td>2 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Anaphylaxis preparedness (n=271)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discuss any of the symptoms of anaphylaxis</td>
<td>65 (73.9)</td>
<td>74 (80.4)</td>
<td>37 (40.7)</td>
<td>176 (64.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cell ambulance after using epinephrine autoinjector</td>
<td>54 (61.4)</td>
<td>60 (65.2)</td>
<td>49 (53.9)</td>
<td>163 (60.1)</td>
<td>0.28</td>
</tr>
<tr>
<td>Ask about an action plan for anaphylaxis</td>
<td>4 (4.5)</td>
<td>10 (10.9)</td>
<td>1 (1.1)</td>
<td>15 (5.5)</td>
<td>0.01</td>
</tr>
<tr>
<td>Correctly demonstrate epinephrine autoinjector</td>
<td>8 (9.1)</td>
<td>22 (23.9)</td>
<td>17 (18.7)</td>
<td>47 (17.3)</td>
<td>0.03</td>
</tr>
<tr>
<td>Antihistamines are ineffective in treating acute anaphylaxis</td>
<td>78 (88.6)</td>
<td>87 (94.6)</td>
<td>81 (89)</td>
<td>246 (90.8)</td>
<td>0.30</td>
</tr>
<tr>
<td>Anaphylaxis engagement (n=271)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask about the allergen that caused anaphylaxis</td>
<td>67 (76.1)</td>
<td>67 (72.8)</td>
<td>47 (51.6)</td>
<td>181 (66.8)</td>
<td>0.001</td>
</tr>
<tr>
<td>Confirm seeing an allergy specialist</td>
<td>6 (6.8)</td>
<td>16 (17.4)</td>
<td>32 (35.5)</td>
<td>54 (19.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Physically demonstrate the epinephrine autoinjector</td>
<td>70 (79.5)</td>
<td>72 (78.3)</td>
<td>77 (84.6)</td>
<td>219 (80.8)</td>
<td>0.82</td>
</tr>
<tr>
<td>Provide written material on how to use the</td>
<td>25 (28.4)</td>
<td>21 (22.8)</td>
<td>25 (27.5)</td>
<td>71 (26.2)</td>
<td>0.66</td>
</tr>
<tr>
<td>epinephrine autoinjector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide advice about autoinjector storage</td>
<td>20 (22.7)</td>
<td>16 (17.4)</td>
<td>16 (17.6)</td>
<td>52 (19.2)</td>
<td>0.52</td>
</tr>
<tr>
<td>Check epinephrine autoinjector expiry date</td>
<td>54 (61.4)</td>
<td>36 (41.3)</td>
<td>42 (46.2)</td>
<td>134 (48.4)</td>
<td>0.02</td>
</tr>
<tr>
<td>Explain side effects of epinephrine</td>
<td>7 (8)</td>
<td>9 (9.8)</td>
<td>5 (5.5)</td>
<td>21 (7.7)</td>
<td>0.65</td>
</tr>
<tr>
<td>General anaphylaxis advice provided without prompt</td>
<td>43 (48.9)</td>
<td>47 (51.1)</td>
<td>20 (22)</td>
<td>110 (40.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Antihistamine (AH) advice with sale (n=114)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AH was recommended and sold</td>
<td>43 (48.9)</td>
<td>48 (52.2)</td>
<td>23 (25.2)</td>
<td>114 (42.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Choice of sedating or non-sedating AH offered</td>
<td>5 (11.6)</td>
<td>15 (31.3)</td>
<td>12 (23.7)</td>
<td>21 (18.4)</td>
<td>0.01</td>
</tr>
<tr>
<td>AH dose stated</td>
<td>29 (47.4)</td>
<td>40 (83.3)</td>
<td>9 (23.1)</td>
<td>68 (66.4)</td>
<td>0.001</td>
</tr>
<tr>
<td>If no improvement after AH, use epinephrine</td>
<td>24 (55.8)</td>
<td>33 (68.8)</td>
<td>8 (34.8)</td>
<td>65 (57)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*Pearson χ² p value for comparison of demographic variables across all epinephrine autoinjector groups.  
†Fisher’s exact p value for comparison of demographic variables across all epinephrine autoinjector groups where expected cell counts <5 in at least 25% of cells.

(n=15, 5.5%). Demonstrations were significantly poorer in the original EpiPen group (n=8 correct; p=0.05), while only one pharmacist in the Anapen group asked about an action plan (p=0.01 compared to other groups; figure 2, table 1).

Anaphylaxis engagement
The mean anaphylaxis engagement score was 3.11 (SD=1.73) out of a possible 8 points (n=271). Scores for new-look EpiPen were similar to original EpiPen and Anapen (3.11 vs 3.32 points; 3.11 vs 2.90 points, both p=0.42), although there were differences in the points addressed by pharmacists. While most performed a hands-on demonstration with the epinephrine autoinjector or a trainer device (n=219, 80.8%), less were willing to provide written material (n=71, 26.2%). Two-thirds asked about the allergen that caused anaphylaxis (n=181, 66.8%), however only 54 (19.9%) of pharmacists asked whether the patient was seeing an allergy specialist (significantly more of them from the Anapen group;...
n=32, p=0.001). Half of the pharmacists checked the expiry date of the autoinjector (n=134, 49.4%), with significantly more checking the original EpiPen expiry (n=54, p=0.02). Few pharmacists explained the side effects of epinephrine (n=21, 7.7%) or provided advice about autoinjector storage (n=32, 19.2%). Less than half of the pharmacists provided antihistamine advice before the antihistamine ‘prompt’ question was asked by the patient (n=110, 40.6%), with significantly fewer of them in the Anapen group (n=20, p=0.001; figure 2, table 1).

**Factors impacting on anaphylaxis preparedness**

Two factors associated with anaphylaxis preparedness were identified in the multiple regression model: anaphylaxis engagement score and type of epinephrine autoinjector. For each additional engagement point identified by the pharmacist, anaphylaxis preparedness increased by 7% (0.557 points; 95% CI 0.291 to 0.424; p<0.001). Relative to original EpiPen (set as reference level), the new look EpiPen was associated with an 11% increase (0.548 points; 95% CI 0.307 to 0.789; p=0.001) in anaphylaxis preparedness. There was a non-significant decrease of 4.5% with Anapen (-0.225 points; 95% CI -0.560 to 0.006; p=0.12). Pharmacy type and location, pharmacist gender, estimated age and busyness and the time of day the visit was performed did not significantly impact on anaphylaxis preparedness, and were excluded from the final model. The fitted model equation was: anaphylaxis preparedness score=1.091+0.548 (new look EpiPen)+0.3577 (engagement score); adjusted R²=0.327.

**Antihistamine recommendations**

There were 114 pharmacists who sold an antihistamine to the patient. Sales were similar for original EpiPen and new look EpiPen (around 50% of visits included a sale), but significantly fewer for Anapen (25% of visits, p=0.001). There was some diversity in antihistamines recommended and sold. Where sales were made, 45 (39.5%) were for first-generation H1 antagonists and 69 (60.5%) were for second-generation H1 antagonists; p=0.139. The most frequently sold antihistamine was fexofenadine (42.1%), followed by desloratadine (21.1%), promethazine (18.4%), loratadine (12.3%), cetirizine (4.4%), levocetirizine and desloratadine (both 0.9%); p=0.05.

**DISCUSSION**

**Principal findings**

The Pharmacists’ Response to Anaphylaxis in the Community (PRAC) study was the first to measure community pharmacists’ management of anaphylaxis. We found pharmacists were not fully prepared for anaphylaxis emergencies. Overall, they provided sound advice on anaphylaxis symptoms, the need for emergency care after epinephrine and the role of antihistamines. However, most pharmacists did not correctly demonstrate the epinephrine autoinjector and very few identified the need for an anaphylaxis action plan. Pharmacists appeared to be more at ease with the new look EpiPen than any other device, consistently scoring higher on all anaphylaxis preparedness measures (and thus overall score) when demonstrating this device. Despite being directly sought by the
patient, pharmacists missed the opportunity to fully engage in a discussion about anaphylaxis, with less than half initiating the discussion unprompted. On average, just three out of eight elements of anaphylaxis engagement were addressed. However, engagement remains vitally important: pharmacists who engaged in a discussion about anaphylaxis with the patient, also demonstrated a greater preparedness for anaphylaxis emergencies.

**Strengths and limitations**

A key strength of the PRAC study was the use of simulated patient methodology. This technique is well described in the literature as a tool to measure true pharmacist practice, and overcomes the issues of participant bias that occur when pharmacists know they will be evaluated. Simulated patient methodology has been adopted worldwide in pharmacy practice research, and is an intrinsic part of quality use of medicines assessment in Australia.

There are other strengths in our study design. Our random sample of 300 pharmacies represented over 70% of all pharmacies in the Perth metropolitan area. We defined anaphylaxis preparedness and engagement based on national and international pharmacy practice and anaphylaxis guidelines. The scenario and data collection tool were developed using a rigorous approach, with training, evaluation and pilot testing undertaken prior to the study. Finally, our study had sufficient power to detect a 10% or greater difference in mean anaphylaxis preparedness score between groups.

However, there are potential limitations with the PRAC study. As we did not seek ethics approval to conduct concealed audio or video recordings and instead relied on researchers to remember details of each encounter before completing the data collection tool, this study was subject to recall bias. Our results may underestimate pharmacists’ true preparedness scores, as simulated patient recall has been shown to underestimate real behaviour by 10–20%. Although pharmacists performed better overall using the new-look EpiPen, this effect may have been confounded by features unique to the simulated patient (e.g., age, gender, personality and memory). We did not measure whether the pharmacist advised the anaphylaxis patient to lay flat. We acknowledge that an upright position is associated with fatal anaphylaxis, and not measuring this important element of advice may distort anaphylaxis preparedness. We included all points stated by the pharmacist, whether they were provided before or after the antihistamine ‘prompt’ question. Although this may have overstated anaphylaxis preparedness or anaphylaxis engagement, we considered this aspect of the scenario important to allow pharmacists a reasonable opportunity to demonstrate their management of patients with anaphylaxis. For pharmacists to achieve all points required an extended consultation for which the pharmacist could not expect to be remunerated, and this may have affected willingness to engage in discussion.

Furthermore, we did not include workload in our definition of busyness, and could not account for attitudes to provision of information where the pharmacist had not supplied the epinephrine autoinjector. Nonetheless, in this regard pharmacists performed admirably, providing advice for free and genuinely aiming to assist the simulated patient. Such practice mirrors the ethos of Australian professional practice standards, where the pharmacist’s primary concern is the health and well-being of the patient.

**PRAC relative to other research**

Anaphylaxis management in pharmacy practice has not previously been defined or holistically evaluated. Although aspects of pharmacist management have been assessed (using survey data), the evidence for anaphylaxis preparedness or engagement is limited by few studies. A retrospective survey of 1887 patients with food-anaphylaxis found pharmacists’ advice provision to be poor. In first-time epinephrine autoinjector supplies (similar to our recently diagnosed patient), 86.6% of pharmacists provided no advice, 13.4% provided information about epinephrine (7.7% in PRAC); 2.3% discussed the signs of an allergic reaction (69.4% in PRAC) and 13.9% provided autoinjector training (89.8% in PRAC).

Device demonstration accuracy in PRAC was just 17.5%, but this was better than or similar to demonstration accuracy in other studies (15.8% of school teachers, 2% of hospital doctors, 2% of general practitioners and 25% of physicians were accurate). In a small survey of pharmacists’ proposed actions, 55.6% of pharmacists were unsure or unwilling to administer an EpiPen in a hypothetical anaphylaxis emergency. The main deterrent was concern about liability, and this adds an important dimension to anaphylaxis preparedness that could not be evaluated in our study. The broader literature indicates elements of anaphylaxis advice (identification and management of anaphylaxis; willingness to provide advice), and autoinjector technique (ability and intention to demonstrate) are suboptimal among health professionals and patients.

Although some of the results for PRAC are similar, this evidence predominately relates to isolated assessments and unlike the PRAC study, does not represent overall anaphylaxis management at a given point in time. In other simulated patient research pharmacist advice is frequently reported as suboptimal. Pharmacists may fail to conduct a complete patient assessment before product sale, or undertake comprehensive medicines discussion with the patient. In a study of advice for back pain, pharmacists addressed a median of 5/13 elements of advice, similar to our (mean) 3/8 for engagement. In other research, the pharmacist provided correct advice with a sale of drug for insomnia but there was room for improvement in general insomnia advice. This was similar to PRAC where all antihistamine sales were appropriate and included sound advice, but anaphylaxis engagement was inadequate. Seemingly, pharmacists provide the information they perceive as

Implications and recommendations
Historically the role of the pharmacist in anaphylaxis management was to supply epinephrine autoinjectors on prescription. However, for a raft of reasons this role is beginning to change. Anaphylaxis is now the new epidemic in public health, and in any single year, 1 in 12 patients who have suffered anaphylaxis will experience recurrence. Compliance with carrying and using epinephrine autoinjectors is poor. While expert opinion recommends patients self-treat with epinephrine and then attend hospital, in practice this may be difficult. Furthermore the first episode of anaphylaxis can be fatal and pharmacists may be the closest health professional available in the crucial early stages, where treatment may save a life. Finally, it is impossible to control or predict the actions of a desperate person during a frightening, life-threatening emergency, and some will choose to attend a pharmacy. The recent death of a girl with acute anaphylaxis, who was refused treatment by a pharmacist in Ireland, highlights the importance of pharmacist preparedness.

The PRAG study demonstrates pharmacists are conversant with the symptoms of anaphylaxis, the need for emergency care after epinephrine and the role of antihistamines in anaphylaxis. However, the majority of pharmacists could not correctly demonstrate an autoinjector under everyday conditions, and therefore we question their preparedness for emergency situations. Further the apparent lack of awareness of anaphylaxis action plans raises concern. Although the benefit of such plans in anaphylaxis has not formally been established, they are widely recommended and likely provide reassurance alongside the treatment algorithm they represent.

Pharmacists worldwide have the opportunity to practise their anaphylaxis preparedness every time they supply an autoinjector. New-look EpiPen was associated with significantly greater preparedness than other devices. In the absence of a clear difference in the proportion of correct device demonstrations compared to Anapen it is not possible to explain this irregularity and we caution against translating this finding to different levels of preparedness depending on the autoinjector. Although simply engaging the patient in a general discussion about anaphylaxis improves recall of life-saving preparedness points, pharmacists do not reliably do this. There has been a call for epinephrine autoinjectors to be made available in all public places where anaphylaxis might occur, and pharmacies represent a logical choice for such a location. However, incomplete anaphylaxis preparedness limits the potential for this option. The ‘Orange Cross’ scheme promoted through Community Pharmacy Scotland identifies pharmacies that stock high-dose and low-dose autoinjectors, where pharmacists are trained and prepared to provide emergency care in acute anaphylaxis. Such a scheme offers a safe option for patients with anaphylaxis and may provide the infrastructure to support anaphylaxis practice guidelines for pharmacists.

Future research
Less than 20% of pharmacists correctly demonstrated all autoinjector administration steps on the relevant ASCIA Action Plan for Anaphylaxis. There is an urgent need to investigate the intricacies of autoinjector demonstration by pharmacists to identify the nature and significance of errors made in demonstration, and the relevance of this to anaphylaxis preparedness.

To improve anaphylaxis preparedness, we should improve anaphylaxis engagement. Research to develop and implement anaphylaxis practice guidelines for pharmacists is an important step in providing guidance for pharmacists to discuss as well as to prevent anaphylaxis.

To further safeguard patients with anaphylaxis in the Australian community, development and pilot of a programme similar to the ‘Orange Cross’ scheme would be useful. A well-designed programme may also alleviate pharmacist concerns about liability and costs associated with provision of epinephrine as first aid for patients with anaphylaxis presenting to the pharmacy.

Conclusions
Anaphylaxis in the community presents challenges in management. Pharmacists are a potential destination for patients with acute anaphylaxis. This covert assessment of pharmacist advice identified strengths and weaknesses in anaphylaxis preparedness. Pharmacists demonstrated reasonable knowledge of anaphylaxis symptoms and emergency care, but had poor epinephrine autoinjector technique and rarely discussed anaphylaxis action plans. Pharmacists who engaged their patients in a more comprehensive discussion about anaphylaxis were more prepared for anaphylaxis emergencies. Future research should evaluate the nature and significance of errors in pharmacists’ autoinjector technique and fully discuss anaphylaxis action plans.

Pharmacists engaged their patients in a more comprehensive discussion about anaphylaxis were more prepared for anaphylaxis emergencies. Future research should evaluate the nature and significance of errors in pharmacists’ autoinjector technique and fully discuss anaphylaxis action plans.

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Contributors: SMS designed the study, conceived the scenario and data collection tool, conducted tool validation, analysed the data, interpreted results and drafted the manuscript. BS and SEK assisted with tool design and validation and collected the data. RMS assisted with interpretation of results. All authors contributed to and approved the final version of the paper.

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5.3 Key points from this chapter

- Preparedness for anaphylaxis emergencies was defined based on five key statements from the WAO and ASCIA.\textsuperscript{1, 2} In this study pharmacists addressed a mean of 2.39 out of the 5 statements during their consultation with the simulated patient, and thus did not demonstrate sound preparedness for anaphylaxis emergencies.

- There were statistically significant differences in the mean number of preparedness statements addressed by pharmacists across the different adrenaline autoinjector groups, although in all cases the difference was small (less than one statement).

- One of the five key statements for anaphylaxis preparedness was correct demonstration of the adrenaline autoinjector. This task is critical to save lives.\textsuperscript{3-6} When assessed against the four steps for correct autoinjector use (published on the ASCIA Action Plan for Anaphylaxis)\textsuperscript{1}, pharmacists had poor adrenaline autoinjector technique, with just 17.3% accurately demonstrating all four steps. This reinforces concerns that pharmacists are not prepared to manage anaphylaxis in the community. The nature and significance of errors in autoinjector demonstration must be investigated.

- Additional statements from the WAO and ASCIA were supported by concepts from the Australian Professional Practice Standards and National Competency Standards Framework for Pharmacists in Australia,\textsuperscript{7, 8} with eight statements identified to define willingness of the pharmacist to discuss anaphylaxis with the patient. This concept is important, as pharmacists should engage anaphylaxis patients at every opportunity. In this study, pharmacists addressed a mean of 3.11 out of 8 statements during their consultation with the patient; disappointingly they missed the opportunity to provide the essential reminders and cues that patients need to self-
manage anaphylaxis in the community. The scores did not change based on the adrenaline autoinjector demonstrated by the pharmacist.

- There was a trend for pharmacists demonstrating the Anapen to be reticent to take responsibility to educate the patient, compared to those demonstrating the EpiPens. For example, only 50% of pharmacists in the Anapen group asked if the patient knew what they reacted to, compared to around 70% in the Epipen groups. Just 20% of the Anapen group discussed anaphylaxis without a prompt compared to 50% in the EpiPen groups; and only 40% in the Anapen group explained the symptoms of anaphylaxis, compared to 80% in the EpiPen groups. There is no clear evidence for the cause of this, although it is possible that the complexity of the Anapen device impacted pharmacists’ ability to provide holistic care.

- Although a similar proportion of pharmacists across groups (90%) identified antihistamines were ineffective in treating anaphylaxis, more pharmacists in the EpiPen groups still sold an antihistamine to the patient compared to Anapen (50% vs 25%). Of concern where a sale occurred, only 56% of pharmacists in the original EpiPen group, 69% in the new-look EpiPen group and just 35% in the Anapen group reminded the patient to use their adrenaline autoinjector if there was no improvement after taking the antihistamine. This demonstrates a lack of attention to detail and suggests pharmacists did not translate their knowledge in this regard.

- As this was a simulated patient study of pharmacists present in the pharmacy on any given day, it was not possible to determine each pharmacist’s level of anaphylaxis knowledge. Therefore a simple comparison for translation of knowledge to practice was not performed. However, when assessing the features of the pharmacist consultation including pharmacist age/gender, pharmacy characteristics, advice provided and adrenaline autoinjector demonstrated, an association between
willingness to discuss anaphylaxis and preparedness for anaphylaxis emergencies was observed. Pharmacists who had a more comprehensive general discussion about anaphylaxis with the patient were more prepared for anaphylaxis emergencies. This willingness to discuss anaphylaxis likely represents an interest in anaphylaxis or greater anaphylaxis knowledge. While the association suggests knowledge translation did occur in those who knew more about anaphylaxis, significant gaps (including poor adrenaline autoinjector technique) highlight areas of concern for further investigation. There was no relationship between age, gender, or pharmacy characteristics and anaphylaxis preparedness.
5.4 Bibliography


Chapter 6

Investigation of Demonstration Accuracy of Adrenaline Autoinjector Devices by Community Pharmacists

Presented as published in Allergy, Asthma & Clinical Immunology.


6.1 Background

In chapter 4, pharmacists who had received ASCIA anaphylaxis training showed variable understanding of the steps required for adrenaline autoinjector administration, when asked to order the steps in a written test. The majority (87%) demonstrated sound understanding immediately after training, however this changed over time, with only 45-47% able to order the steps at 3 months, and 61-63% able to do so at 7 months. By comparison in chapter 5, pharmacists demonstrated poor adrenaline autoinjector technique with only 17% able to accurately demonstrate a device when asked to do so by a simulated patient in the pharmacy. Both assessments used the same definition for accuracy, although pharmacists in the anaphylaxis training study had the benefit of having all steps (unordered) on the written test, while those in the simulated patient study were required to remember or identify the steps some other way.
It is critical that anaphylaxis patients know how to use their prescribed adrenaline autoinjector correctly. Given that pharmacists supply all adrenaline autoinjectors to patients in Australia, they can uniquely influence patient knowledge. In this context (and notwithstanding the results identified in chapters 4 and 5), it is essential to identify exactly how pharmacists demonstrate these devices in practice (rather than as written tests).

This chapter aims to address the fourth set of research questions by closely assessing adrenaline autoinjector demonstrations by pharmacists to patients. The study specifically sought to identify autoinjector demonstration accuracy (and to pinpoint errors), differences in accuracy based on device (original EpiPen/new-look EpiPen/Anapen), and if any features of the consultation with the pharmacist improved demonstration accuracy.
6.2 Publication

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http://www.aacijournal.com/content/10/1/49

**RESEARCH**

Demonstration of epinephrine autoinjectors (EpiPen and Anapen) by pharmacists in a randomised, simulated patient assessment: acceptable, but room for improvement

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**Abstract**

**Background:** Successful treatment of anaphylaxis in the community relies on early and correct use of epinephrine autoinjectors. Community pharmacists supply these devices and have a crucial role teaching patients how to use them. Supply of epinephrine autoinjectors in Australia increased 70-fold in the past decade. New EpiPen and Anapen autoinjectors were launched in Australia in 2011 and 2012, with the potential to cause confusion. However there is no information about how pharmacists demonstrate epinephrine autoinjectors to patients. Therefore the aim of this study was to assess real-world community pharmacist demonstrations of EpiPen and Anapen. We also sought to identify consultation-based predictors of accurate demonstration.

**Methods:** Demonstration accuracy was assessed in simulated patient visits to 300 randomly selected pharmacies. Pharmacists were asked by the simulated patient how to use original EpiPen, new-look EpiPen or Anapen, and assessed against the relevant Australian Society of Clinical Immunology and Allergy (ASCIA) Action Plan for Anaphylaxis. Other anaphylaxis advice provided by the pharmacist was also recorded. Accuracy was analysed descriptively. Binary logistic regression was used to identify predictors of accurate demonstration.

**Results:** All 300 pharmacies were visited. Of 250 pharmacist demonstrations, 46 (18.4%) accurately demonstrated all four steps on ASCIA Action Plan. Failure to state ‘do not touch the needle’ (74.8%) or ‘massage injection site’ (68.8%) reduced accuracy. However 163 (65.2%) accurately demonstrated the three steps required to inject epinephrine (no difference by device, p = 0.15). Associations with accurate demonstration were: checking if the patient had an anaphylaxis action plan (odds ratio, OR = 16.1; 95% CI: 3.86-67.3; stating to call an ambulance after use (OR = 4.0; 95% CI: 1.44-11.1); or explaining side effects of epinephrine (OR = 4.5; 95% CI: 1.48-13.4).

**Conclusions:** It is critical that anaphylaxis patients know how to use their prescribed epinephrine autoinjector correctly. Pharmacists have acceptable rates of EpiPen and Anapen demonstration accuracy, although more is needed to improve this. Those who pay attention to the need for action plans, emergency care after epinephrine use, and informing patients about the side effects of epinephrine may have better knowledge about anaphylaxis, and in turn significantly improve demonstration accuracy.

**Keywords:** Primary care, Pharmacy practice, Simulated patient, Anaphylaxis, EpiPen, Anapen, Technique, Self-injectable epinephrine, Adrenaline
Background

Anaphylaxis is a severe, progressive, allergic reaction that is rapid in onset and can cause death [1]. Anaphylaxis in the community is common, and increasing as severe allergies to food and insect venom rise [2-5]. Early treatment with epinephrine is essential to reduce mortality [6-10]. However, in the community setting, this can represent a potentially deadly challenge for patients without immediate access to a healthcare professional. Epinephrine autoinjectors are frequently prescribed to anaphylaxis patients to enable rapid first aid before medical attention is sought [8,9,11]. Although not universally available, these devices exist in Australia, Canada, the United States, Europe, the United Kingdom, Asia, Africa, South America, and the Middle East [12].

In Australia, epinephrine autoinjectors (EpiPen and Anapen devices) may be obtained with or without a physician’s prescription [13,14]. Devices supplied on prescription are subsidised through the Medicare Australia Pharmaceutical Benefits Scheme (PBS). Supply is restricted to patients who have experienced anaphylaxis, or who have been declared high-risk for anaphylaxis, by a specialist allergist, pediatrician, emergency room physician or respiratory physician. Before the listing of Anapen in 2010, EpiPen was the sole device available in Australia. A new-look EpiPen became available in 2011, and for a period all three devices were sold (original EpiPen, new-look EpiPen, Anapen). In 2003, PBS funding for epinephrine autoinjectors totalled AUS$188,000. In 2013, this had risen to nearly AUS$13 million; almost a 70-fold increase [15]. All of these devices were prescribed by physicians, and supplied to patients by pharmacists in community pharmacies.

It is well established that teaching patients how and when to use their autoinjector is central to sound anaphylaxis preparedness and management [5,6,10,11,16]. Alongside an understanding of the importance of timely injection is the need for correct injection technique. Erroous injection, typically to a digit or hand, results in a lost dose of epinephrine for the patient (a potentially fatal error), as well as injury to the caregiver [17,18]. Vigilance in training and reminding patients on correct the use of epinephrine is crucial to prevent anaphylaxis deaths. Physicians provide this training during consultations, although when assessed they have been shown to be poor demonstrators of autojectors [19-22]. Patients have been shown to be inconsistent with recall, and need to be regularly reminded how to use their device [20-22,27].

Pharmacists are an important link for interdisciplinary care between physician and patient. As pharmacists see patients every time an epinephrine autoinjector is supplied, they have a unique role in teaching them how to use their device. Yet there is little research evaluating this. Studies in this area are limited to evaluation of EpiPen demonstration rates and open assessment of EpiPen demonstration steps [19,28]. There is no blinded research assessing real-world epinephrine autoinjector technique in pharmacists, patients or other health professionals. Although Anapen is available in the United Kingdom, Europe and Australia, there is no research evaluating its demonstration by pharmacists, and few evaluations in other groups [23,27].

Our primary aim was to investigate how accurately Australian community pharmacists demonstrated epinephrine autoinjectors to patients under real-world conditions. Pharmacists are routinely exposed to these devices, therefore we hypothesized they would have high rates of demonstration accuracy. Secondly, we considered that changes in epinephrine autoinjector availability in Australia (in 2010–2011) would cause confusion, and hypothesized that demonstration accuracy would vary between devices. In this instance we expected pharmacists would be most familiar with original EpiPen (as for more than 10 years this was the only device available in Australia); but not familiar with Anapen (a new device with different administration technique). Since new-look EpiPen was replacing original EpiPen (and they have similar technique), we expected accuracy to be similar between these devices, and higher in both compared to Anapen. Finally, we sought to identify predictors of accurate demonstration based on the features of the consultation with the pharmacist.

Methods

We conducted a randomised, cross-sectional, simulated patient study of community pharmacist practice in Perth, Australia, from April-May 2012. Approval for the study was received from The University of Western Australia Human Research Ethics Committee in March 2012 (Approval number RA/4/1/5440). A random sample of 300 pharmacies located within a 20 km radius of the Perth Central Business District, and listed on the Pharmacy Registration Board of Western Australia Premises Register [13] was selected using a random numbers generator [29]. Pharmacies were randomly assigned to original EpiPen, new-look EpiPen or Anapen groups. Where the researcher recognised the pharmacist or any other staff member on duty, the visit was abandoned and the pharmacy excluded.

Devices were allocated to researchers randomly. Original EpiPen was allocated to a female Master of Pharmacy student, aged 20–25 years. New-look EpiPen was allocated to a male Master of Pharmacy student, aged 20–25 years. Anapen was allocated to an experienced simulated patient actor (female, aged 40–45 years). At each visit the researcher enacted a scenario of a patient who had experienced their first episode of anaphylaxis ‘one week ago’. Researchers carried two of the same unmarked, epinephrine autoinjector devices. All devices were new and within their expiry date, and replenished as required to ensure they appeared new for each pharmacy
visit. At the pharmacy, the researcher asked for the pharmacist on duty, before showing their device and asking how to use it. Immediately after the visit (away from the premises) the researcher completed a data collection tool and subsequently entered data into a database [Microsoft Excel, Microsoft Corporation, Redmond, United States of America].

Prior to the study, we assessed the usability of the scenario during a full-day training and evaluation session. Researchers practised the role of the simulated patient, and learnt a 'script' so that all opening scenario statements and responses to pharmacist questions were the same for each pharmacist. Questions that might be asked by the pharmacist were anticipated and responses practised during the training session. If a pharmacist asked any question beyond those anticipated and for which responses had been pre-prepared, researchers answered either ‘I can’t remember’ or ‘I don’t know’. EpiPen and Anapen trainers were used to teach researchers correct device demonstration, and device technique assessed to ensure accuracy.

The data collection tool captured demographic variables (broadly: pharmacy environment, pharmacist age group and gender), and self-injectable epinephrine variables (broadly: materials used for demonstration, use of references, steps used in demonstration, errors or omissions in demonstration and other advice provided). Prior to use, the tool was evaluated for face validity in a group of ten pharmacists and evaluated for usability in a round-table discussion during the training session. The scenario and data collection tool were piloted in a random sample of 9 pharmacies (3 per device). The scenario remained unchanged. Minor changes to the tool were made prior to the main study. Pharmacists visited in the pilot were not included in the final analysis. During the study, an independent auditor cross-checked a random sample of 30 completed tools against data entered in the database. The proportion of records in disagreement was 0.27%. Data in disagreement were corrected in the database prior to analysis.

We did not seek ethics approval to conduct concealed video or audio recordings in this study because demonstration is a moving visual and tactile task that is difficult to record covertly. In addition, audio recordings would not have been able to identify important features of the demonstration such as order of removal of safety caps, positioning of thumb, selection of location for injection and most importantly, which end of the device was shown as the needle end.

Accurate demonstration of epinephrine autoinjectors was defined as one that fulfilled all steps listed on the relevant Australasian Society of Clinical Immunology and Allergy (ASCIA) Action Plan for Anaphylaxis [30]; (Table 1). Errors and omissions in demonstration were recorded, along with materials used for demonstration and any additional advice provided by the pharmacist.

**Analysis**

All analyses were performed using SPSS v21 [IBM, New York, United States of America], and statistical tests reported as two-sided p-values at the 5% level of significance. Data are presented as frequencies, with associations tested using the Pearson chi-squared test or Fisher’s exact test. Compounding pharmacies and private hospital dispensaries were excluded from analysis as they may not routinely supply epinephrine autoinjectors or be directly accessible by patients.

Binary logistic regression was performed to identify consultation-specific predictors of accurate EpiPen and Anapen demonstration. Potential predictors in the model were device type, age, gender, use of references, and general anaphylaxis and device-specific information provided by the pharmacist. Recognising that consultations with pharmacists may vary from brief to extended interactions (and thus to assess the impact of predictor variables independently and collectively), we conducted both single variable and multi variable (adjusted) logistic regression analyses. Odds ratios and 95% confidence intervals for each predictor were obtained.

**Results**

We visited all 300 pharmacies randomised to the study. We excluded 34 pharmacies (pilot study n = 9, known pharmacist n = 9, private hospital dispensary n = 8, premises

| Table 1 Steps for an accurate demonstration of epinephrine autoinjectors* |
|--------------------------------------------------|-------------------|------------------|
| **Original EpiPen** | **New-Look EpiPen** | **Anapen** |
| Step 1: Remove safety caps | Form a fist around EpiPen and remove grey safety cap | Form a fist around EpiPen and pull off blue safety release | 1. Pull off black needle shield |
| Step 2: Place against thigh | Place black end against outer mid thigh (with or without clothing) | Place orange end against outer mid thigh (with or without clothing) | 2. Pull off grey safety cap from red button |
| Step 3: Push and inject | Push down hard until a click is heard or felt and hold in place for 10 seconds | Push down hard until a click is heard or felt and hold in place for 10 seconds | Place needle end firmly against outer mid-thigh (with or without clothing) |
| Step 4: Remove and massage site | Remove EpiPen and do not touch needle | Remove EpiPen. Massage injection site for 10 seconds | Press red button so it clicks and hold in place for 10 seconds. |

*Steps as listed on the relevant ASCIA Action Plan for Anaphylaxis at the time of this research [28].
vacant n = 4, compounding pharmacy n = 3, pharmacist not on premises n = 1). Hence, 266 (89%) of the visits were included in the final analysis. Despite randomisation, there was significant variability in the type/location of pharmacies visited and estimated pharmacist age, between EpiPen and Anapen groups. There was no difference in pharmacist gender between groups (slightly more were female: n = 155; 58.3%, p = 0.94); Table 2.

**Demonstration accuracy**

Of the 266 pharmacists asked to demonstrate a device, 16 (6%) refused (4 for original EpiPen, 5 for new-look EpiPen and 7 for Anapen). Overall, 46/250 (18.4%) pharmacists who agreed to demonstrate the device accurately demonstrated all four steps of the relevant ASCIA Action Plan (significantly fewer for original EpiPen than new-look EpiPen or Anapen, p = 0.04; see Table 2). Overall, 222 (88.8%) pharmacists correctly demonstrated removal of safety caps (step 1), and 290 (96.0%) correctly demonstrated placement of the device against the mid-anterothal thigh (step 2). Furthermore, 182 (72.8%) pharmacists correctly demonstrated how to inject (step 3). However, only 52 (20.8%) pharmacists correctly advised what to do with the device after injection (step 4). Considering the first 3 steps as those integral to receiving a dose of epinephrine, a total of 163/250 (65.2%) pharmacists completed these correctly (Table 3), with no difference between device groups (p = 0.15).

There was no difference in demonstration accuracy based on pharmacy type (p = 0.29 for comparison of 4-step accuracy, and p = 0.42 for comparison of 3-step accuracy; across independent, chain and discount pharmacies). Similarly, accuracy did not differ by pharmacy location (p = 0.89 for comparison of 4-step accuracy, and p = 0.86 for comparison of 3-step accuracy; across street, shopping centre, and medical centre locations).

**Demonstration errors**

The most frequent errors in demonstration were failure to state 'do not touch the needle' after injecting original EpiPen or Anapen (n = 122/163, 74.8%), or 'massage injection site after use' (n = 172/250, 68.8%); Figure 1. Other common errors included failure to state 'hold in place for 10 seconds' after injection (n = 70/250, 28%); or 'push down hard/press the red button until a click is heard' (n = 53/250, 21.2%). Incorrect positioning of the thumb over either end of the EpiPen was observed in 20/170 (11.8%) pharmacists.

**Demonstration materials and anaphylaxis advice**

Significantly more pharmacists in the Anapen group demonstrated using the researcher’s live device (82.5% compared to 59.4% for EpiPen, p < 0.001, see Table 4). Few pharmacists used their own trainer devices (3.6% for original EpiPen, 24.1% for new-look EpiPen and 6.3% for Anapen) with the most use occurring in the new-look EpiPen group, p < 0.001. Over half (58.4%) of the pharmacists consulted reference materials including

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**Table 2 Pharmacy and pharmacist characteristics (count and %)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Original EpiPen n = 87 (32.7)</th>
<th>New-look EpiPen n = 92 (34.6)</th>
<th>Anapen n = 87 (32.7)</th>
<th>Total n = 266 (100)</th>
<th>P value&lt;sup&gt;2&lt;/sup&gt;</th>
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<td>36 (41.4)</td>
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<td></td>
</tr>
<tr>
<td><strong>Pharmacists</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.94</td>
</tr>
<tr>
<td>Male</td>
<td>35 (40.2)</td>
<td>39 (42.4)</td>
<td>37 (42.5)</td>
<td>111 (41.7)</td>
<td></td>
</tr>
<tr>
<td>Estimated age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>20-30</td>
<td>35 (40.2)</td>
<td>46 (50)</td>
<td>25 (28.7)</td>
<td>106 (39.8)</td>
<td></td>
</tr>
<tr>
<td>31-40</td>
<td>32 (36.8)</td>
<td>20 (21.7)</td>
<td>34 (39.1)</td>
<td>86 (32.3)</td>
<td></td>
</tr>
<tr>
<td>41-50</td>
<td>11 (12.6)</td>
<td>18 (19.6)</td>
<td>22 (25.3)</td>
<td>51 (19.2)</td>
<td></td>
</tr>
<tr>
<td>51+</td>
<td>9 (10.3)</td>
<td>8 (8.7)</td>
<td>6 (6.9)</td>
<td>23 (8.6)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>2</sup>Pearson chi-squared p-value for comparison of demographic variable categories across groups.
Table 3 Accuracy of self-injectable epinephrine device demonstration (count and %)

<table>
<thead>
<tr>
<th>Demonstration performed</th>
<th>Original EpiPen (n = 83)</th>
<th>New-look EpiPen (n = 87)</th>
<th>Anapen (n = 80)</th>
<th>Total (n = 250)</th>
<th>P value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>61 (73.5)</td>
<td>76 (87.4)</td>
<td>75 (93.8)</td>
<td>222 (86.8)</td>
<td>0.11</td>
</tr>
<tr>
<td>Step 2</td>
<td>80 (96.4)</td>
<td>84 (96.6)</td>
<td>76 (95)</td>
<td>240 (96.0)</td>
<td>0.86</td>
</tr>
<tr>
<td>Step 3</td>
<td>82 (77.4)</td>
<td>59 (67.8)</td>
<td>61 (76.3)</td>
<td>182 (72.8)</td>
<td>0.42</td>
</tr>
<tr>
<td>Step 4</td>
<td>8 (95)</td>
<td>26 (29.9)</td>
<td>18 (22.5)</td>
<td>52 (20.8)</td>
<td>0.005</td>
</tr>
<tr>
<td>Steps 1-3</td>
<td>56 (67.2)</td>
<td>54 (62.1)</td>
<td>59 (73.8)</td>
<td>163 (65.2)</td>
<td>0.15</td>
</tr>
<tr>
<td>Steps 1-4</td>
<td>8 (96)</td>
<td>21 (24.1)</td>
<td>17 (21.3)</td>
<td>46 (18.4)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*Pearson chi-squared p-value for comparison of demonstration accuracy across groups. Step 1: Remove safety caps; Step 2: Place against mid-lateral thigh; Step 3: Push down hard/press red button to inject and hold for 10 seconds; Step 4: Remove device, avoid needle, massage site. *Remove black needle shield. Remove gray safety cap from red button (Anapen only).

books, websites and the device itself before attempting to demonstrate, with 80-90% referring the researcher to the instructions on their device during demonstration. Of those consulting reference materials, 25/146 (17.1%) proceeded to accurately demonstrate the device (1 for original EpiPen, 10 for new-look EpiPen and 14 for Anapen; p = 0.002 for group comparison). However, 96/146 (65.8%) correctly demonstrated steps 1–3 (26 for original EpiPen, 33 for new-look EpiPen and 37 for Anapen; p = 0.04 for group comparison).

Most pharmacists explained the signs of anaphylaxis (65.4%, see Table 5), asked if the researcher was aware of the precipitating allergen (66.9%), told the researcher to call an ambulance after using epinephrine (59.8%), and examined the expiry date of the device (99.6%). Pharmacists rarely checked if the patient had an anaphylaxis action plan (5.6%), or explained the side effects of epinephrine (7.9%). Compared to those demonstrating the EpiPens, significantly fewer pharmacists demonstrating Anapen explained the signs of anaphylaxis (p < 0.001), asked about the precipitating allergen (p = 0.001); or checked if the researcher had an anaphylaxis action plan (p = 0.02); Table 4.

Predictors of accurate demonstration

Odds ratios (OR) from the logistic regression models for predictors of accurate device demonstration are presented in Table 6. There were three significant predictors identified in both the simple and multiple regression analyses. Accurate demonstration (as part of the consultation) was more likely to occur when pharmacists: (i) asked about an anaphylaxis action plan (adjusted OR 16.1, 95% CI: 3.86–67.3); (ii) advised the researcher to call an ambulance after epinephrine use (adjusted OR 4.00, 95% CI: 1.44–11.1); or (iii) explained the side effects of epinephrine (adjusted OR 4.45 95% CI: 1.48–13.4). Additionally, in brief consultations where pharmacists may have provided just one piece of additional advice, simply explaining the signs of anaphylaxis or the conditions for device storage doubled the likelihood of accurate demonstration (OR 2.14 and 2.16 respectively). Age and gender did not impact on whether the pharmacist

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![Figure 1 Errors and omissions in epinephrine autoinjector device demonstration by pharmacists.](image-url)
provided accurate demonstration. There was no difference in accuracy between new-look EpiPen and Anapen groups. However, those demonstrating the original EpiPen were 4.8 times less likely to do so accurately compared with the Anapen group (95% CI: 1.59-14.3; p = 0.006). Finally, the use of reference materials prior to demonstration did not impact on the likelihood of accurate demonstration.

Discussion
Self-injectable epinephrine is the cornerstone of emergency management for anaphylaxis occurring in the community, and accurate administration technique is critical for successful use during acute events. This is the largest study of epinephrine autoinjector demonstration by community pharmacists, and the only study in any health profession to evaluate demonstration technique in a blinded manner. Further, this is the first study to assess differences in demonstration accuracy between original EpiPen, new-look EpiPen and Anapen.

Main findings
Overall, 65% of pharmacists accurately demonstrated the first three steps required for epinephrine injection. However, only 18% of pharmacists performed all four steps listed on the ASCIA Action Plan for Anaphylaxis [30] with the proportion being twice as high for new-look EpiPen and Anapen than for original EpiPen. Thus despite more than 10 years of uninterrupted use of original EpiPen in Australia, pharmacists performed worse when demonstrating this device compared to the new devices. Seemingly familiarity with a device does not guarantee sound technique; rather being 'unusual' or 'new' may serve to make the user more careful.

In the broader context no other evaluation of device technique has assessed the fourth step (remove device after injection, do not touch needle, massage injection site for 10 seconds). It is possible that pharmacists considered this last step did not require explanation, as it is obvious the device needs to be removed after injection. Furthermore, the importance of massaging the site is unknown, although it may provide comfort from the puncture of the needle. Studies of epinephrine autoinjector demonstration in physicians and patients focus only on the three steps required for injection of original EpiPen. These show that 21-41% of allergy specialists [19,22]; 11-37% of other medical practitioners [19,21,31,32]; and 9-36% of patients and caregivers [25,26] accurately performed those three steps. Therefore, against the 4-step ASCIA standard [30] pharmacists had a low proportion who demonstrated accurately, whereas in comparison with previous research (3-step evaluation), pharmacists had the highest proportions of accurate demonstrators.

Although all of the autoinjectors have the same cost and are subsidised equally on the PBS, EpiPen is more widely prescribed in Australia [15,33]. We expected demonstration accuracy to be similar between the EpiPens

Table 4 Materials used by pharmacists in self-injectable epinephrine device demonstration (count and %)

<table>
<thead>
<tr>
<th>Description</th>
<th>Original EpiPen (n = 83)</th>
<th>New-look EpiPen (n = 87)</th>
<th>Anapen (n = 80)</th>
<th>Total (n = 250)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher’s live device</td>
<td>50 (60.2)</td>
<td>51 (58.6)</td>
<td>66 (82.5)</td>
<td>167 (66.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pharmacist’s trainer device</td>
<td>3 (3.6)</td>
<td>21 (24.1)</td>
<td>5 (6.3)</td>
<td>29 (11.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Consulted reference materials before demonstration</td>
<td>44 (53.0)</td>
<td>56 (64.4)</td>
<td>46 (57.5)</td>
<td>146 (58.4)</td>
<td>0.25</td>
</tr>
<tr>
<td>Showed instructions on researcher’s device</td>
<td>75 (90.4)</td>
<td>81 (93.1)</td>
<td>64 (80.0)</td>
<td>220 (88.0)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Pearson chi-squared p-value for comparison of materials used for demonstration across groups.

Table 5 Additional advice provided by pharmacists during consultations (count and %)

<table>
<thead>
<tr>
<th>Advice provided</th>
<th>Original EpiPen (n = 87)</th>
<th>New-look EpiPen (n = 87)</th>
<th>Anapen (n = 80)</th>
<th>Total (n = 266)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you know what you reacted to?</td>
<td>66 (75.9)</td>
<td>67 (72.8)</td>
<td>45 (51.7)</td>
<td>178 (66.8)</td>
<td>0.001</td>
</tr>
<tr>
<td>Explain signs of anaphylaxis*</td>
<td>64 (73.6)</td>
<td>74 (80.4)</td>
<td>36 (41.4)</td>
<td>174 (65.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Call ambulance after using epinephrine</td>
<td>58 (68.0)</td>
<td>60 (65.2)</td>
<td>46 (52.9)</td>
<td>159 (59.8)</td>
<td>0.23</td>
</tr>
<tr>
<td>Identify expiry date of researcher’s device</td>
<td>53 (60.9)</td>
<td>38 (41.3)</td>
<td>41 (47.1)</td>
<td>132 (49.0)</td>
<td>0.03</td>
</tr>
<tr>
<td>Are you seeing an allergy specialist?</td>
<td>6 (69)</td>
<td>16 (17.4)</td>
<td>30 (34.5)</td>
<td>52 (19.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Conditions for device storage</td>
<td>20 (23)</td>
<td>16 (17.4)</td>
<td>15 (17.2)</td>
<td>51 (19.2)</td>
<td>0.49</td>
</tr>
<tr>
<td>Side effects of epinephrine</td>
<td>7 (8)</td>
<td>9 (8.8)</td>
<td>5 (5.7)</td>
<td>21 (7.9)</td>
<td>0.61</td>
</tr>
<tr>
<td>Do you have an anaphylaxis action plan?</td>
<td>4 (4.6)</td>
<td>10 (10.9)</td>
<td>1 (1.1)</td>
<td>15 (5.6)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Pearson chi-squared p-value for comparison of advice provided across groups.
*Pharmacist explained the signs of severe allergic reaction as listed on the relevant ASCIA Action Plan for Anaphylaxis at the time of this research [30].
*Fishor's exact test used.
but poorer in the Anapen group. Therefore it was surprising that 4-step accuracy was significantly worse for original EpiPen, and that there was no difference in 3-step accuracy between all 3 devices. Given this research was conducted in the midst of the change in device availability it is possible pharmacists had been exposed to promotional materials from the new autoinjector manufacturers, or had undertaken self-directed learning to address a perceived unfamiliarity with new-look EpiPen and Anapen.

Features of the consultation associated with accurate demonstration

Our study found that three elements of the pharmacist’s advice showed an association with accurate device demonstration. Firstly, the odds of an accurate demonstration was 16 times higher if the pharmacist asked the researcher ‘do you have an anaphylaxis action plan?’ in Australia, patients prescribed epinephrine autoinjections on a PBS prescription must also receive an anaphylaxis emergency management plan [33]. These plans are prepared by the specialist allergist and rarely seen by the patient’s pharmacist. Only 5.6% of pharmacists in this study asked about an action plan, and in practice less than half of all anaphylaxis patients actually have an action plan [34,35]. Yet there is immense potential for improvement in device demonstration, patient preparedness and understanding of anaphylaxis with their use [3,8,11,36,37]. Judicious use of device-specific anaphylaxis action plans in pharmacist consultations may improve demonstration accuracy (especially since the steps for demonstration are shown on the plan), while reminding patients of the need to obtain their own plan.

Advising the researcher to call an ambulance after epinephrine use was associated with a four-fold increase in the odds of an accurate demonstration, and explaining the side effects of epinephrine was associated with a 4.5 fold increase in the odds of an accurate demonstration. Although 60% of pharmacists in this study recognised the need for emergency care after epinephrine use, [3,7,10,38-41] less than 10% of pharmacists explained the side effects of epinephrine. Provision of medicines and other information is fundamental to professional pharmacist practice [42], and although there are benefits to the patient in providing such advice (empowerment, comfort with intended use [43,44]), these elements cannot alone predict technical expertise or accurate autoinjector demonstration. Rather, they likely reflect a more detailed understanding of anaphylaxis and epinephrine autoinjector devices, and it is this deeper knowledge that contributes to improved autoinjector demonstration accuracy.

Predictors of accurate epinephrine device demonstration by physicians and patients relate to their experiences. Regular allergy assessment, history of severe anaphylaxis and recognition of the device are important predictors of
demonstration accuracy in physicians, while practical demonstration, prior consultation with a specialist and empowerment (including independently seeking information) impact patient technique \cite{21,24,43,45}. Given this was a simulated patient study and pharmacists were unaware they were being assessed, it was not possible to measure experience as a predictor of accurate demonstration.

**Relevance of demonstration errors**

Common errors in demonstration were similar to those observed in other studies \cite{19,21,22,24,31,32,46}. Failure to activate the device (5-21% of pharmacists), or to hold it firmly in place for 10 seconds after injection (28%) prevents or reduces the intramuscular dose of epinephrine received. Positioning the thumb over either end of EpiPen (11.8%) may result in unintentional injection to the thumb and a lost dose for the patient. These errors are of concern in one-third of visits where the researcher would not have received epinephrine had they followed the pharmacist's instructions.

More than two-thirds of pharmacists in our study did not inform the researcher of the fourth step: avoid the exposed needle (original EpiPen and Anapen), and massage the site after injection. These statements are clearly defined in device-specific ASCIA Action Plans for Anaphylaxis and in manufacturer information \cite{30,47-49}, but are not printed in the instructions on either live or trainer epinephrine autoinjector devices. There is no information on the frequency or hazards of needle-stick injury after intentional epinephrine autoinjector use. While the clinical implication of failure to massage after injection is unclear, a slower rate of epinephrine absorption or injection site discomfort may be relevant. The lack of any research amongst physicians, patients or carers involving this step suggests it is not perceived to be important in device administration. Similarly, it is likely that pharmacists do not consider these ‘after-injection’ steps as relevant to receiving a dose of epinephrine. As this research is the first to evaluate the fourth step, future consideration of the need for this step in inclusion in manufacturer information, patient leaflets and anaphylaxis action plans is needed. As a minimum, consistency across information sources (written materials and autoinjector devices) should be a priority.

**Strengths and limitations**

In previous research on epinephrine autoinjector demonstration, users were 2.6 times more likely to perform accurate demonstration when informed that the technique would be assessed \cite{50}. Therefore a key strength of this study was the use of simulated patient methodology to blind pharmacists to their assessment. This technique is well described in the literature as a tool to measure true pharmacist practice, and overcomes the issues of participant bias that occurs when pharmacists know they will be evaluated \cite{51,52}. Further, it is common in Australia for patients to request advice over-the-counter at a pharmacy without a product sale or prescription purchase, so we did not consider the request would arouse suspicion.

However, because we solicited the pharmacist's advice without a sale, we could not evaluate true patterns of device demonstration that may occur when an epinephrine autoinjector is actually dispensed. Moreover, the complexities of PBS subsidies and high cost of self-injectable epinephrine (currently more than AUS100 for one EpiPen or Anapen) \cite{33} preclude such an evaluation.

As we did not record the exchange between pharmacist and simulated patient, we relied on researchers to remember the consultation with the pharmacist and acknowledge that recall bias was possible. Further we note that the use of Master of Pharmacy students as simulated patients presented the potential for bias in scenario delivery or responses to pharmacist questions, although we aimed to minimise this with predefined statements for each researcher to use. In addition, as all three simulated patients required sound knowledge of anaphylaxis and epinephrine autoinjector technique (to be able to judge and record the consultation), we cannot be sure how a lay consumer would interpret and remember the consultation. Nor did we evaluate whether the pharmacist asked the researcher to demonstrate the device back to them, and in turn assess the true understanding gained as a result of the pharmacist demonstration. This is an essential part of device training and a gap in research that should be addressed.

Finally, although we found three elements of pharmacist advice were associated with significantly higher odds of accurate demonstration (both independently and collectively), they do not predict accurate demonstration within themselves, but represent better knowledge of anaphylaxis and autoinjector technique in general.

**Implications and recommendations**

This study showed pharmacists were willing to demonstrate EpiPen and Anapen devices to patients even when they had not supplied them and would not receive remuneration for the service. Two-thirds of pharmacists under the blinded real-world conditions of our study provided sound demonstration advice, compared to one-third of physicians in open evaluations \cite{19,31,32}. Thus despite concerns that pharmacists are poor demonstrators \cite{53} we may be reassured that most can show their patients how to inject a dose of epinephrine. For the one-third of pharmacists who failed to do so accurately, the use of device-specific anaphylaxis action plans during demonstration may prompt improved accuracy.

While we recognise the importance of an holistic approach in autoinjector device training, pharmacists
are a sound option for training in the periods when physician review is not possible. Patients may wait months after diagnosis for an appointment with their allergy specialist, or only see their general practitioner when a new prescription is required to replace an expired device (every 1–2 years) [10]. Consultations may be time-restricted and patients may be overwhelmed with new information, reducing the potential for a memorable device demonstration by physicians. In-time retraining of autoinjector technique by pharmacists should be considered to raise patients’ awareness and competence with autoinjector devices.

Dealing with the errors in device technique is essential, yet may be difficult to achieve because aspects critical for epinephrine injection (such as pushing hard to inject, holding the device in place for 10 seconds, or using the correct thumb position) are not intuitive. Novel approaches should be developed for training. Beyond this training is the need to prevent errors in the high-stress environment of acute anaphylaxis. Performing device demonstrations under pressure (such as with a timer), and then evaluating patient technique similarly would be useful to prepare patients to work quickly in real emergencies.

Conclusions
Pharmacists in Australia dispense prescriptions for epinephrine autoinjectors 70 times more often now than ten years ago [15]. Given their important role, and significant potential in anaphylaxis preparedness, it is disappointing that only 18% of them accurately demonstrated all four steps for autoinjector administration listed on the ASCIA action plan for anaphylaxis [30]. However, the fourth step is not relevant to the patient receiving a dose of epinephrine and has not been tested in any other research. Moreover 65% of pharmacists accurately demonstrated all 3 steps required for epinephrine injection from an autoinjector. Notably, this is the best demonstration accuracy observed in any health professional group. Nonetheless there remains room for improvement. Raising awareness of the need for action plans, emergency care after epinephrine use, and informing patients about the side effects of epinephrine may prompt recall of epinephrine autoinjector technique and improve demonstration accuracy. This in turn may improve epinephrine autoinjector use in the community and save lives.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
SS designed the study, conceived the scenario and data collection tool, conducted tool validation, analysed the data, interpreted results and drafted the manuscript. RL assisted with scenario design and interpretation of results. FS assisted with analysis and interpretation of results. AC assisted with study design, tool development and interpretation of results. All authors contributed to and approved the final version of the paper.

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13. Health Department, Government of Western Australia; Pharmaceutical Services Branch. Supplying schedule 3 medicines. [In http://www.health.wa.gov.au/anaphylaxis/SH3/]


Cite this article as: Salter et al.: Demonstration of epinephrine autoinjectors (Epipen and Anapen) by pharmacists in a randomised, simulated patient assessment: acceptable, but room for improvement. Allergy, Asthma & Clinical Immunology 2014, 10:49.
6.3 Key points from this chapter

- Accurate demonstration was defined as that fulfilling the four steps for adrenaline autoinjector administration listed on the relevant ASCIA Action Plan for Anaphylaxis.1 [Step 1 – remove safety cap/s; Step 2 – place against mid anterolateral thigh; Step 3 – push and inject/press red button/hold 10 seconds; Step 4 – remove EpiPen/Anapen and don’t touch needle/massage site].

- Of the pharmacists who were asked to demonstrate a device, 18.4% accurately demonstrated all four steps of the relevant ASCIA Action Plan for Anaphylaxis, while a further 6% refused to demonstrate. Based on the 4-step definition, original EpiPen was associated with significantly poorer demonstration accuracy compared to new-look EpiPen and Anapen. This accuracy rate is similar to that observed in doctors and patients/carers, where only steps 1-3 have been used to define accurate autoinjector demonstration.2-8

- Based on a definition of steps 1-3 as those essential to receive a dose of adrenaline, 65% of all pharmacists performed accurate demonstration. There was no difference in accuracy between autoinjector groups at this level. Compared to other health professionals, this represents significantly higher demonstration accuracy rates.

- The most frequent errors were related to step 4, and were observed in over 69% of pharmacists. Demonstration errors similar to those in other studies2, 3, 5, 7-10 (including failure to activate the device, insufficient time allowed for injection, and incorrect thumb position) were observed in less than one-third of pharmacists. However, these are clinically of greater concern than simply omitting step 4 as they result in a lost dose of adrenaline.

- When assessing the features of the pharmacist consultation that may impact on accurate autoinjector demonstration (including pharmacist age/gender, advice
provided and device demonstrated), awareness of anaphylaxis action plans; the need for emergency care after adrenaline; and explaining the side effects of adrenaline were associated with accurate demonstration. Such associations do not confer technical expertise, although they do suggest a more detailed understanding of anaphylaxis and adrenaline autoinjector devices generally, and may indicate knowledge translation.

• Notably, the action plan for anaphylaxis stands out in its association with accurate demonstration. This document may prove a useful tool for advice provision, either on its own, or as part of the development of anaphylaxis practice guidelines for pharmacists.
6.4 Bibliography


Chapter 7

Discussion
7.1 Background

This thesis considered the holistic role of the community pharmacist in caring for people at risk of anaphylaxis. It represents the first work assessing Australian pharmacists in the context of anaphylaxis knowledge and management; and is the first in the world to directly assess how pharmacists interact with anaphylaxis patients. The overarching feature of all aspects of anaphylaxis care (and a priority of the World Allergy Organization) is education,\(^1, 2\) therefore this thesis has an educational focus. Through a series of original studies, this thesis examined the feasibility of delivering anaphylaxis education to pharmacists online; implemented and evaluated the effectiveness of anaphylaxis training for pharmacists (delivered online and as face-to-face lectures); and assessed how pharmacists in the community educate people at risk of anaphylaxis about their condition and its management.

This chapter integrates the principal findings from each of the studies to explain anaphylaxis knowledge and preparedness, in view of the pharmacist’s role in the community care of people at risk of anaphylaxis. Critical consideration of the research along with implications for policy and practice are discussed. Finally, new perspectives for research are identified.

7.2 Principal Findings

The first area of research examined the effectiveness of e-learning in pharmacy education with a strategic view to deliver a standardised anaphylaxis education program, accessible to all pharmacists in Australia. The systematic review in Chapter 3 demonstrated that pharmacists consider e-learning to be a highly acceptable instructional format, and that it increases knowledge immediately after training. However, many of the e-learning studies included in the review did not use validated
tools to assess outcomes and there was no evidence for long-term effectiveness. This suggested e-learning would be a feasible option to enable widespread delivery of standardised anaphylaxis education to pharmacists, although questions around long-term effectiveness of this instructional format remained. Therefore when implementing ASCIA anaphylaxis training for pharmacists, it was important to identify long-term effectiveness of the program using a suitably validated tool. A further finding of the systematic review was that there was no evidence for assessment of the application of knowledge gained through e-learning to practice. This is a crucial aspect of knowledge translation that relates equally to knowledge gained through traditional learning methods. Therefore examination of how pharmacists communicate anaphylaxis knowledge to patients was assessed in a real world setting.

The second, third and fourth research areas focussed specifically on anaphylaxis knowledge and education to address evidence gaps identified in Chapter 3, as well as specific questions relating to pharmacist preparedness for anaphylaxis. These research areas were presented in Chapters 4-6.

7.2.1 Anaphylaxis knowledge

The second and third research areas considered pharmacists’ knowledge of anaphylaxis. This was assessed in two ways. Firstly anaphylaxis knowledge was assessed directly through a validated 12-question test, administered on four occasions over a 7-month period. The first of these tests (before anaphylaxis training) represented baseline knowledge. In this test, pharmacists had poor knowledge of anaphylaxis and adrenaline autoinjector technique. Less than 46% achieved the minimum standard for knowledge and only 34% were able to correctly order the steps for autoinjector administration. Knowledge improved significantly immediately after training with almost 100% of
pharmacists achieving the minimum standard and over 87% correctly ordering autoinjector steps. There was evidence of long-term knowledge change, with over 80% of pharmacists achieving the minimum standard after 7 months. However, ability to order the autoinjector steps declined, with just over 60% of pharmacists able to do so at 7 months.

Secondly, anaphylaxis knowledge was assessed indirectly in a random visit to pharmacists by simulated patients. Here, knowledge was measured based on how pharmacists responded (to the simulated patient) in the five key statements identified as those crucial to treating acute anaphylaxis (defined as ‘anaphylaxis preparedness’). Mean scores for anaphylaxis preparedness were 2.39 out of a possible 5 points, demonstrating that in practice, pharmacists again showed incomplete anaphylaxis knowledge. Due to the anonymity of simulated patient research, it was not known (or able to be identified) if the pharmacists in the simulated patient study had also undergone ASCIA anaphylaxis training, although the timing of each of the research projects could have allowed it. Even if the pharmacists had undergone training, these poor scores for preparedness demonstrate limited application of knowledge to practice. Interestingly, 65% of the pharmacists in the simulated patient study were able to correctly order the first 3 steps for autoinjector administration in a hands-on demonstration, (and as such, if this were a written test, the final step would be obvious). This is similar to the proportion of pharmacists in the ASCIA anaphylaxis training study who correctly ordered the autoinjector steps in a written test 7 months after training (60%), and much higher than those who could do so before training (34%).

Seemingly, pharmacists in the simulated patient study demonstrated only baseline anaphylaxis knowledge but performed above baseline in autoinjector
demonstrations. This was probably because they were able to identify the steps for autoinjector administration (on the device or in some other reference) and not because of better knowledge. Therefore, a written checklist for pharmacists to remind them of key anaphylaxis points may similarly improve knowledge or its’ application to practice. Currently, no such documents for pharmacists exist in Australia.

The broader evidence for anaphylaxis knowledge in pharmacists is limited by few studies. In a large US survey of first-time adrenaline autoinjector supplies to newly diagnosed food allergy patients (similar to our simulated patient), 86.6% of pharmacists provided no advice, 13.4% provided information about adrenaline (7.7% in my research), 2.3% discussed the signs of an allergic reaction (64.9% in my research) and 13.3% provided autoinjector training (65.2% did so accurately in my research). Compared with that study, Australian pharmacists provided more advice and were more attuned to anaphylaxis. However, it is difficult to make knowledge comparisons between the patient survey and the more formal assessments applied in my research. Furthermore the lack of any other studies testing anaphylaxis knowledge in pharmacists means the work in this thesis is foundation work, and should drive ongoing research. The fact that my research identified that gaps in anaphylaxis knowledge in pharmacists can be addressed with appropriate training is particularly encouraging. Importantly, the one-hour time commitment required for ASCIA anaphylaxis training is not onerous, and the e-learning program may be completed at no cost at a time that suits the individual. Improving knowledge is the fundamental starting point to improving anaphylaxis morbidity and mortality, and pharmacists should be regularly encouraged to update and maintain their knowledge with a program that is known to be effective, such as the ASCIA anaphylaxis training program.
7.2.2 Knowledge translation and patient education

The third and fourth areas of research focussed on how pharmacists in the community educate people at risk of anaphylaxis about their condition and its management, and represents application of knowledge to practice. This turning of ‘knowledge into action’ is a key component of knowledge translation, and in this research served as an indicator of pharmacist preparedness for managing anaphylaxis. A simple framework for indicators of knowledge-to-action translation was proposed by Straus et al in 2010. In this framework there are three indicators. Structural indicators focus on organisational aspects of provision of service, and are analogous to instrumental use of knowledge. Process-related indicators focus on care delivered to patients and include instances when evidence is communicated to patients and carers (again instrumental use of knowledge). Outcome-related indicators refer to the ultimate goal of care, such as quality of life of patients or admission to hospital.

In this thesis, both structural and process-related indicators of anaphylaxis knowledge translation (and thus preparedness) were examined. The use of anaphylaxis action plans and trainer adrenaline autoinjectors in advice provision represent structural indicators, and were poorly addressed by pharmacists in the simulated patient study. Less than 6% of pharmacists referred to anaphylaxis action plans, and less than 12% used a trainer autoinjector when teaching the simulated patient how to use their device. Pharmacists may be unaware of anaphylaxis action plans, or perceive them not to be an important part of pharmacist advice, because they must be initiated by a specialist allergist at the point of prescribing an adrenaline autoinjector. However, awareness of the need for an anaphylaxis action plan was associated with a 16-fold increase in the odds of performing accurate adrenaline autoinjector demonstration. Currently there is no requirement for pharmacists to use anaphylaxis action plans when providing advice...
Chapter 7

to people at risk of anaphylaxis. This is in contrast to Western Australian asthma guidelines where the adult asthma action plan includes a section for use by community pharmacists.13, 14

The process-related indicators, anaphylaxis advice and accuracy of adrenaline autoinjector demonstration, were also examined in this thesis. Demonstration of application of anaphylaxis knowledge by pharmacists (when providing advice) was inconsistent and incomplete. Pharmacists variably addressed predefined anaphylaxis preparedness statements during simulated patient consultations, with further differences seen between Anapen and EpiPen groups (40-80% identified the symptoms of anaphylaxis, and 53-65% advised the patient to call an ambulance after autoinjector use).6 This knowledge-to-action gap suggests either pharmacists did not have the requisite knowledge to manage anaphylaxis, or they were unable to apply it in practice (even in the low-stress scenario used in this research). Either way, this could result in a serious outcome for the patient. Further, although a similar proportion of pharmacists in Anapen and EpiPen groups (89-94%) identified that antihistamines were ineffective in treating anaphylaxis, 25-50% still sold an antihistamine to the simulated patient.6 In these sales, only 35-69% of pharmacists advised the simulated patient to use their Anapen or EpiPen if there was no improvement after the taking the antihistamine. This demonstrates poor knowledge-to-action translation in the crucial area of over-the-counter medicine supply, where pharmacists should be the experts.15, 16 It is possible that Anapen, being the newer autoinjector (and one with quite different administration technique), unnerved pharmacists who had been asked to demonstrate it. Notably, Anapen requires the removal of two safety caps before use (unlike one for EpiPen), and uses thumb pressure over the end of the device to activate it (unlike EpiPen, which does not use the thumb, and is activated using direct force). With pharmacists’ attention
diverted to demonstration of this unfamiliar autoinjector, the quality of their anaphylaxis counselling may have been affected. As pharmacists become familiar with Anapen, these differences may abate.

There were two interpretations of accurate adrenaline autoinjector demonstration applied in this thesis. The first judged pharmacists on a 4-step demonstration that matched the published guidelines for autoinjector administration,\textsuperscript{5, 17-19} but included the impractical (and obvious) step: remove the device after injection and massage the injection site. The second judged pharmacists on a 3-step demonstration that matched the instructions printed on both live and trainer adrenaline autoinjectors. Only 17.3\% of pharmacists accurately demonstrated all 4 steps for autoinjector administration,\textsuperscript{6} whereas 65.2\% accurately performed the 3-step demonstration.\textsuperscript{7} Given 66\% of pharmacists consulted the instructions on the simulated patient’s adrenaline autoinjector before demonstration, the accuracy of demonstration may reflect how well pharmacists could read, interpret and teach the instructions printed on the device, and not knowledge-to-action translation. These results suggest teaching adrenaline autoinjector technique is more complex than simply knowing the steps, or even reading them immediately before instruction, and this may be applicable whether pharmacists or patients are the student. How this translates to administration of an autoinjector in an anaphylaxis emergency is unknown.

No other evaluation of autoinjector demonstration (in any group or setting) has assessed the 4-step standard. Therefore, pharmacists have much higher rates of demonstration accuracy when compared with other groups who were tested for accuracy using 3-step demonstrations (21-41\% of allergy specialists;\textsuperscript{20, 21} 11-37\% of other medical practitioners;\textsuperscript{20, 22, 23} and 9-36\% of patients and carers\textsuperscript{24, 25}). Nonetheless, the 35\% gap in autoinjector demonstration accuracy in pharmacists must be improved, as
errors in autoinjector use may prove fatal for the patient.

There are no other studies of pharmacist advice or adrenaline autoinjector demonstration to anaphylaxis patients. However, the broader literature indicates elements of anaphylaxis advice (identification and management of anaphylaxis; willingness to provide advice), and autoinjector technique (ability and intention to demonstrate) are suboptimal among other health professionals and patients.8, 21, 26-32

This thesis identified gaps in anaphylaxis knowledge and adrenaline autoinjector technique in pharmacists, including gaps in knowledge-to-action translation, through objective assessments at the care-provider level. There is a need to improve care and education of anaphylaxis patients and carers by health providers in the community. Given their presence in the community, pharmacists should play a fundamental role in delivering this anaphylaxis care and education. The findings of this thesis set the foundations upon which to guide and improve how pharmacists manage people at risk of anaphylaxis in the community.

7.3 Limitations of the Research

The studies undertaken for this thesis included a systematic review of the literature, a controlled intervention study, and a randomised cross sectional simulated patient study. The relative strengths and limitations of each approach were discussed in Chapters 3-6. Additional consideration of the key limitations of the findings, in context of the aims of the thesis [to explore pharmacists’ real-world preparedness for anaphylaxis, in terms of education, knowledge and the interaction between pharmacists and people at risk of anaphylaxis] is presented here.
7.3.1 Limitations to findings for preparedness for anaphylaxis in terms of education and knowledge

Participants in the controlled intervention study were recruited using a convenience method either when attending an ASCIA anaphylaxis lecture, or when logging on to the ASCIA anaphylaxis e-learning program for pharmacists. Therefore they either had an interest in the topic, or recognised a deficiency in their own knowledge and as such were motivated to learn before enrolment in the study. Accordingly baseline and subsequent changes in anaphylaxis knowledge may have differed from the broader population, and thus impacted on external validity. Although anaphylaxis training was provided in lecture format only in Perth, Western Australia, it was presented using a standardised program (that includes a dedicated set of PowerPoint slides available for use by any ASCIA presenter in Australia or New Zealand), and this would not have impacted on external validity.

The need to lay the patient flat during acute anaphylaxis is an essential component of anaphylaxis management.1, 33, 34 This was not examined in knowledge tests and may have distorted true knowledge and anaphylaxis preparedness. Further, my study did not test whether ASCIA anaphylaxis training improves real technique for administering the adrenaline autoinjector, as steps for autoinjector administration were listed (unordered) in the tests themselves. These limitations do not affect external validity of the effectiveness of the anaphylaxis training program, but may limit explanations of pharmacists’ preparedness for anaphylaxis in terms of knowledge. Finally, this research assessed knowledge up to 7 months after training. Therefore conclusions about persistence of knowledge are limited to this timeframe.
7.3.2. Limitations to findings for preparedness for anaphylaxis in terms of the interaction between pharmacists and people at risk of anaphylaxis

The randomised simulated patient study (through direct request) assessed only pharmacists’ preparedness for anaphylaxis. Pharmacy assistants routinely greet patients at the counter, provide advice, sell medicines (including antihistamines), and often hand out prescriptions that have been dispensed by pharmacists. As this research was concerned with pharmacist preparedness, pharmacy assistants were deliberately excluded. However, the findings of the research may not be generalisable to how anaphylaxis patients are managed when they present to pharmacies in general. In addition, simulated patients requested demonstration of the adrenaline autoinjector and asked about the use of antihistamines in anaphylaxis. Therefore there may be a difference in autoinjector demonstration or provision of anaphylaxis advice, when an adrenaline autoinjector is dispensed or an antihistamine is simply requested over-the-counter.

The sampling frame included all pharmacies located within a 20km radius of the Perth CBD. This may limit generalisability to regional or rural areas, where pharmacists may have closer relationships with patients. Moreover pharmacists in rural areas often have different roles from their city counterparts, especially with regards to emergency care in towns without medical practitioners.

The use of only three simulated patients presented the potential for bias, as different patients (for example, parents with young anaphylactic children, or people in whom English is a second language), may evoke different reactions by the pharmacist. Therefore, the results for the different devices may be a reflection of the pharmacists’ responses to the three simulated patients, rather than being associated with the devices themselves. However, the use of large numbers of simulated patients must be balanced
with cost and consistent scenario delivery. Further, it is noted that reliability of visits improves with the number of visits conducted. Finally, although recording of consultations (using audio or video techniques) is recommended in simulated patient research, it was not performed in this research as it is difficult to record physical demonstrations covertly. This may have resulted in recall bias, with a different estimation of pharmacist preparedness. However, it is important to acknowledge that real patients are subject to the same recall bias, given they don’t record their consultations with the pharmacist.

### 7.4 Implications for Policy and Practice

Traditionally, community management of anaphylaxis has focused on discharge planning for the patient after initial treatment of acute anaphylaxis in a healthcare setting. Key strategies include preparation for self-treatment of anaphylaxis recurrence, confirmation of anaphylaxis triggers, and prevention of future episodes of anaphylaxis. Central to this model is the specialist allergist, with input from general practitioners, allergy nurses and dietitians, and although the intention is to prepare the patient for living with anaphylaxis, the model is focussed on medical care and lacks consideration of the important role that pharmacists play in the care of anaphylaxis patients.

Once the patient returns to the community, they may have to wait many months for specialist review, and subsequently may only see a medical practitioner when they require a new prescription for an adrenaline autoinjector (every 1-2 years). Perhaps not surprisingly then, compliance with carrying and using adrenaline autoinjectors is poor, even though expert opinion recommends patients use them to self-treat anaphylaxis in the community, before attending a hospital. Furthermore, this
model does not consider the actions of people experiencing their first episode of anaphylaxis, many of whom may visit their local pharmacy for antihistamines or first aid.

Therefore there is a gap in the care of known and new anaphylaxis sufferers in the community. Given their accessibility and role in primary health care, community pharmacists should logically address this gap. They have been identified as an underutilised resource for providing anaphylaxis education and device training at the time of adrenaline autoinjector supply. However until now there has been little evidence for their role in practice, or how prepared they are to undertake such a role. Further there is no formal recognition of the role of the pharmacist within the existing Western Australian Anaphylaxis Model of Care.

This thesis provides evidence of pharmacists’ anaphylaxis knowledge (and how to improve it), and identifies strengths and weakness in pharmacists’ education of anaphylaxis patients. This evidence should be used to direct the development of a novel framework for Australian community pharmacists in anaphylaxis management. The framework for pharmacists should encompass:

1. Provide anaphylaxis advice
   - A clear statement on advice for patients is required. Pharmacists in this research did not provide adequate anaphylaxis advice to prepare the patient to self-manage in the community. Only 40% of pharmacists provided any advice without a prompt.
   - An antihistamine statement is required. Most pharmacists recognised that antihistamines are ineffective in managing anaphylaxis, yet only 35-69% of them advised the patient to use an adrenaline autoinjector if there was no improvement after taking the antihistamine.
• A guide to refer patients with complicated or unconfirmed allergy is required. Despite knowing the patients in this research had anaphylaxis, only 20% of pharmacists identified the need for specialist review.  

2. Be prepared for an anaphylaxis emergency

• A written emergency protocol is required to enable pharmacists to recognise and respond to anaphylaxis in the community. Pharmacists did not demonstrate knowledge in practice that would confer preparedness to manage acute anaphylaxis, although their knowledge after anaphylaxis training was sound. The ASCIA Action Plan for Anaphylaxis (General) could be displayed in pharmacy work areas as a suitable written protocol. This ‘general’ anaphylaxis action plan takes the form of an A3-sized poster and excludes the patient specific sections that appear on the A4-sized ‘personal’ action plans for anaphylaxis.

• Develop a pharmacy scheme similar to the ‘Orange Cross’ scheme to identify anaphylaxis-ready pharmacies and enable early intervention with adrenaline. This assists in fulfilling calls for a system that makes adrenaline autoinjectors easily available in public places, in case of anaphylaxis emergencies in new or unprepared patients. Additional consideration of pharmacist training and adrenaline autoinjector funding is required in the development of such a scheme.

3. Dispense adrenaline autoinjectors, teach patients how to use them, and provide autoinjector education

• Ensure familiarity with the different brands of adrenaline autoinjector available in Australia. Pharmacists in this research had lower scores for anaphylaxis preparedness when demonstrating Anapen compared to EpiPen.

• A clear protocol for autoinjector demonstration is required. One third of pharmacists
could not correctly order or demonstrate the steps for adrenaline injection.\textsuperscript{4, 7} The use of device-specific anaphylaxis action plans during demonstration may prompt improved accuracy and enhance anaphylaxis preparedness.\textsuperscript{6, 7}

- Additional autoinjector advice statements are required to provide depth of knowledge. Few pharmacists in this research explained the side effects of adrenaline, or autoinjector storage, although an association was identified between awareness of these points and accurate autoinjector technique.\textsuperscript{7}

- Early education for pharmacists about new adrenaline autoinjectors released in Australia is essential. Currently there are two devices available in Australia – EpiPen and Anapen. Additional devices exist worldwide including Emerade,\textsuperscript{48} Jext,\textsuperscript{49} Auvi-Q,\textsuperscript{50} and Adrenaclick\textsuperscript{51} (along with its generic, epinephrine injection USP autoinjector\textsuperscript{52}). Each has a different administration technique. The Auvi-Q is particularly interesting as it has a compact rectangular shape (easier for carrying), and voice prompts to guide injection.\textsuperscript{50}

4. Confirm the patient has an ASCIA Action Plan for Anaphylaxis

- It is a requirement that all patients prescribed adrenaline autoinjectors on PBS prescriptions must also receive an anaphylaxis emergency management plan,\textsuperscript{12} yet only 5.6\% of pharmacists in this research identified the need for this plan.\textsuperscript{6}

- The anaphylaxis action plan defines symptoms and treatment of anaphylaxis and underpins management.\textsuperscript{5, 53}

- A strong association between accurate autoinjector demonstration and awareness of the anaphylaxis action plan was identified in this research.\textsuperscript{7}
5. Undertake regular training to improve and maintain anaphylaxis knowledge

- Accurate and current anaphylaxis knowledge is an essential aspect of anaphylaxis management.\textsuperscript{1,38} Just 45\% of pharmacists in this research achieved the minimum standard for anaphylaxis knowledge without training.\textsuperscript{4}

- Continuing education should apply strategies shown to be effective at transferring knowledge.\textsuperscript{10} ASCIA anaphylaxis training was highly effective at improving pharmacists’ anaphylaxis knowledge immediately and for 7 months after training (over 80\% achieved the minimum standard for anaphylaxis knowledge at 7 months).\textsuperscript{4}

- Anaphylaxis and adrenaline autoinjector knowledge declines over time. A suitable interval for retraining needs to be defined. Further research may be required to do so.\textsuperscript{4}

- The inclusion of a statement on legal liability in treating a patient with acute anaphylaxis in the pharmacy is important for role definition.\textsuperscript{6,54}

7.5 Future Research

The conclusions and limitations of the studies in this thesis generate further questions for research. These include questions specifically related to study findings and limitations, as well as new areas relevant to community care of anaphylaxis patients. Future directions for research are outlined below.

1. Assess anaphylaxis knowledge in a random sample of community pharmacists to identify true background knowledge and areas of weakness, to guide improvements to anaphylaxis training. The AT-PAsT should be updated to include assessment of
understanding of the ‘lay flat’ message, and a hands-on assessment of adrenaline autoinjector technique should be undertaken.

2. Conduct further follow up tests of pharmacists’ knowledge in participants from the anaphylaxis training study (Chapter 4). This is important to define a suitable interval for retraining.

3. Anaphylaxis preparedness and adrenaline autoinjector technique should be assessed in pharmacists in rural/regional areas where access to medical care may be limited. A rural pharmacists’ framework for care of anaphylaxis patients should be considered in the design of this research.

4. Develop and pilot a framework for Australian community pharmacists in anaphylaxis management. Pilot research should recruit both pharmacists and patients to identify the impact of the framework on pharmacist performance and patient understanding.

5. Consideration of the role of pharmacy assistants in the care of allergy patients is essential. This is particularly relevant where requests for over-the-counter medicines are made. Although common, antihistamine requests may flag more serious allergy, and requests for non-dairy or specialised infant formula may flag food allergy. A pathway for assistants to seek pharmacist involvement is essential.

6. The studies in this thesis assessed structural and process-related indicators of knowledge translation. There is a need for outcomes based research, including actual care delivered during acute anaphylaxis, and admission (or readmission) to hospital for anaphylaxis. During the course of my doctoral studies, I designed a population-based study to assess patient outcomes after treatment by paramedics in the community, and/or presentation to hospital, and/or admission to hospital, for acute anaphylaxis (see Appendix 6). I have obtained ethics approval for the study.
from the WA Department of Health and The University of Western Australia. This new study will examine anaphylaxis rates and trends in WA from 1980-2014, and investigate medical and pharmacological management of acute anaphylaxis from 2007-2014 using linked hospital and St John Ambulance records (provided through the WA Data Linkage System, hospital and St John Ambulance notes).

7. Develop and pilot a program that identifies specific pharmacies as ‘anaphylaxis ready’, and enables pharmacists to provide safe and appropriate care to anaphylaxis patients presenting to pharmacies for first aid. The ‘Orange Cross’ scheme provides some information to initiate development. Anaphylaxis training and adrenaline autoinjector funding models must be considered when developing such a program.

7.6 Conclusion

The findings of this thesis demonstrated that e-learning was a feasible option for delivery of anaphylaxis education to pharmacists, but that properly validated tools and long-term follow up were missing from e-learning effectiveness research. Baseline knowledge data identified that pharmacists have limited knowledge about anaphylaxis and adrenaline autoinjector technique. Implementation and evaluation of ASCIA anaphylaxis e-training for pharmacists, showed significant knowledge gains could be achieved immediately and for at least 7 months after training. These gains were similar to ASCIA anaphylaxis lecture training and superior to no training.

The findings also indicate that pharmacists were unable to show (during consultations with simulated anaphylaxis patients) preparedness for anaphylaxis in the community. This either supports evidence of limited knowledge, or represents an issue in transfer of knowledge to practice. Furthermore, most pharmacists did not demonstrate
all four steps listed for adrenaline autoinjector administration, although two-thirds of them correctly demonstrated the three steps required for adrenaline injection.

The research highlights for the first time, a lack of awareness of anaphylaxis and its management in pharmacists, and this is especially important given the increasing incidence of anaphylaxis and the potential for it to occur at any time, in any place. Although training is effective at improving anaphylaxis and adrenaline autoinjector knowledge, issues remain on how pharmacists educate patients about their own preparedness for future anaphylaxis, and autoinjector use. Development of a novel framework for Australian community pharmacists in anaphylaxis management is recommended to address these deficiencies and improve the care of anaphylaxis patients in the community.
7.7 Bibliography


47. Community Pharmacy Scotland (UK). Anaphylaxis campaign. [Internet]. Edinburgh (Scorland): 2014 [cited 2014 Feb 12]; Available from:


Appendices
Appendices

Appendix 1: Effectiveness of e learning for the pharmacy profession: protocol for a systematic review

Citation

Review question(s)
Is e learning an effective form of instruction in pharmacy education?

Searches
A senior reference librarian at The University of Western Australia’s Medical and Dental Library with expertise in conducting systematic literature reviews was consulted as part of the process to develop an initial search strategy. Appropriate electronic databases were identified, with medical subject heading (MeSH) terms and text words identified in accordance with indexing practices.

Electronic databases MEDLINE, EMBASE, CINAHL, Web of Science, Science Direct, ERIC, PsycINFO, Informit, International Pharmaceutical Abstracts, Cochrane Database of Systematic Reviews and Google Scholar will be searched. The following terms will be used:

1. e- (or e) learning or web-based learning or online learning or internet or computer-assisted learning or e training or online training or training, instruction, virtual, distance learning or blended learning, flexible learning
2. pharmacist, pharmacy (pharmac*), intern, prereg*, trainee
3. continued/continuing (continu*) education or education or education program or learning program or knowledge
4. effectiveness or evaluation or assessment or test* or success or satisfaction or acceptability

No restrictions on language or publication period will be placed. If necessary, the search will be iteratively refined. Pearing of reference lists of all full-text articles that meet the inclusion criteria will be conducted.

Electronic sources of grey literature, including OpenGrey, Scirus, Medeaar and, where possible, open access institutional repositories, will also be searched. The search terms will be generally applied as best suited to the specific repository.

Types of study to be included
Predominately quantitative designs including but not limited to:

Randomised controlled trials, controlled before-and-after studies, interrupted time series/multiple time series/other repeated measures designs. Relevant qualitative studies describing effectiveness of e learning in terms of acceptability, participation, or satisfaction will also be included.

Studies evaluating e learning for populations other than the pharmacy profession will be excluded.

Condition or domain being studied
Over the past decade, e learning has become a dominant method of delivering continuing education to pharmacists. In recent years, e learning has increasingly supported, and even replaced, traditional teaching methods in tertiary pharmacy programs. Yet in 2003, very few pharmacists viewed e learning as the best method of education, with <5%
Appendices

Students opting for purely online delivery. Since then, major technological advances have, in part, driven the uptake of e learning as a method to improve professional knowledge. Significant economic resources are dedicated to the development and implementation of e learning programs, despite limited evidence of effectiveness of these programs. Individual approaches have assessed short-term knowledge gain, program acceptability/satisfaction, and pharmacist performance as measures of effectiveness. Just as evidence based medicine forms the basis for clinical therapy, evidence based education should form the basis for clinical education, for it is based on this education that pharmacists practise their profession.

Participants/population
Inclusion criteria:
Pharmacist, intern (or trainee) pharmacist, preregistration pharmacist, pharmacy student.

Exclusion criteria:
Any other person or population receiving or using e learning.

Intervention(s), exposure(s)
E learning intervention of any type, including but not limited to undergraduate, postgraduate or continuing education programs.

E learning refers to the use of various electronic media to support or deliver education, including teaching and learning via the Internet, computer networks, or other virtual media.

Comparator(s)/control
1. No education intervention.

2. Non-electronic education intervention (eg face-to-face lectures).

Outcome(s)
Primary outcomes
Knowledge (eg. change in knowledge scores with repeated tests).

Practice change (eg. guideline implementation).

Improved patient outcome (eg. reduced hospital admissions for known drug interactions, as a result of an e learning program).

Secondary outcomes
Acceptability of e learning (eg. participation rates).

Course satisfaction.

Other secondary outcomes may be defined iteratively as the review progresses.

Data extraction, selection and coding
Study selection:
All articles identified in the search will be exported to an EndNote X5 bibliographic database (where duplicates will be removed), and then uploaded to a web-based, dedicated Distiller SR (systematic review) software account. Two reviewers will independently screen titles and abstracts of all articles identified through the search. Full text articles will be retrieved where abstracts are potentially eligible for inclusion or where there is disagreement between reviewers. Disagreement will be resolved by discussion and consensus or arbitration by a third (moderator) reviewer.

Data extraction:
Two reviewers will independently extract data using standardised data extraction forms in Distiller SR. This software enables coding of extracted data according to predefined criteria set by the reviewer.

The following data will be extracted:

• Participant characteristics
• Learning setting (e learning or other instructional method)
• Study design
• Number of participants
• Topic
• Course characteristics - duration, year conducted, format, frequency
• E learning format (type of electronic media employed)
• Outcome measured – including but not limited to knowledge scores, practice effects, patient outcomes, subjective experience

**Risk of bias (quality) assessment**
Quality assessment will be undertaken using the following tools:

1. Kirkpatrick’s hierarchy (as modified from Kirkpatrick’s model by the Best Evidence Medical Education (BEME) collaboration).

2. EPPI-Centre data extraction and coding tool for education studies (quality of study and weight of evidence sections M and N).

3. Where relevant, the Cochrane Collaboration Risk of Bias tool for quantitative studies.

**Strategy for data synthesis**
A matrix approach to combine themes derived from quantitative data with a separate thematic analysis of qualitative data (where relevant) will be employed. Meta-analytic, thematic synthesis and textual narrative synthesis approaches may be used.

**Analysis of subgroups or subsets**
Professional status (pharmacist, intern pharmacist, pharmacy student).

**Dissemination plans**
This review will be submitted for publication to a peer reviewed journal in the field of pharmacy education.

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Details of final report/publication(s)

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**PROSPERO**

*International prospective register of systematic reviews*

The information in this record has been provided by the named contact for this review. CRD has accepted this information in good faith and registered the review in PROSPERO. CRD bears no responsibility or liability for the content of this registration record, any associated files or external websites.
Appendix 2 – Data abstraction forms used in the systematic review of the literature.

A. Title and abstract screen

| 1. Are the participants pharmacists, pharmacy interns or pharmacy students INVOLVED IN E LEARNING? |
|---------------------------------|---------------------------------|
| Yes                             | No                              |
| Maybe                           |                                |

| 2. Does this paper describe an e-learning process or intervention in the PHARMACY context? E-learning refers to the use of various electronic media to support or deliver education, including teaching and learning via the Internet, computer networks, CDs or other virtual media. It includes virtual, flexible, distance and blended learning. Pharmacy context means the process or intervention is for pharmacists, pharmacy interns or pharmacy students. |
|---------------------------------|---------------------------------|
| Yes                             | No                              |
| Maybe                           |                                |

B. Full-text screen

| 1. Does this article: Evaluate effectiveness and/or acceptability of an e-learning process or intervention for pharmacists, pharmacy interns or pharmacy students? Evaluate also means assess, test or measure. Effectiveness measures may include (but are not limited to) knowledge change (e.g. pre/post-test scores), practice change (e.g. guideline implementation) and patient outcome (e.g. improved diabetes control). E-learning refers to the use of various electronic media to support or deliver education, including teaching and learning via the Internet, computer networks, CDs or other virtual media. |
|---------------------------------|---------------------------------|
| Yes                             | No                              |
| Maybe                           |                                |
### C. Initial study assessment

1. Does this paper give results at the level of the pharmacist, intern pharmacist or pharmacy student?
   - Yes
   - No

2. What was the type of elearning intervention or process?
   - Online (accessed through the internet)
   - CD Rom
   - Computer based program (eg on individual computer hard drive)
   - Blended learning (ONLINE elearning added to other instruction forms such as paper or lecture based instruction)
   - Other (please state)

3. Tick the elearning intervention/s used in the study
   - Online modules (eg powerpoint or another program)
   - Online reading materials
   - Online videos (including recorded material)
   - Online simulated patient (not a simulated patient in a simulation centre)
   - CD rom
   - Computer based program on an individual computer
   - Other elearning intervention (please state)
   - No clear e-learning intervention was used

4. What was the comparator group learning process?
   - No comparator group
   - Didactic face to face lecture
   - No education intervention
   - Paper based intervention (eg textbooks or worksheets)
   - Live interactive workshop [NOT online]
   - Other (please state)

5. Which of the following e-learning effectiveness measures were included?
   - Knowledge (eg change in knowledge)
   - Practice change
   - Patient outcome
   - Course satisfaction
   - Participation rates
   - The e-learning component was not assessed
   - Other (please state)

6. How was e-learning effectiveness assessed? Tick all answers that apply:
   - Pre and post tests (eg MCQ)
   - Likert scales
   - Questionnaire
   - elearning effectiveness was not assessed
   - Other (please state)
### D. Study characteristics

<table>
<thead>
<tr>
<th>1. Are the aims of the study stated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (please copy and paste or briefly summarise the aim)</td>
</tr>
<tr>
<td>No, not at all</td>
</tr>
<tr>
<td>Vague aims stated (can you say?)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Are the study research questions and/or hypotheses stated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (briefly, what were they? Copy and paste from the article if possible, or briefly summarise)</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>I can’t tell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Was the study informed by, or linked to, an existing body of empirical and/or theoretical research?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes clearly</td>
</tr>
<tr>
<td>No, not at all</td>
</tr>
<tr>
<td>It’s hard to tell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. In which country was the study carried out?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please write the name of the country</td>
</tr>
<tr>
<td>The country is not stated or cannot be derived from other information in the paper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. When was the study carried out? (Not when was it published).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please state the year as YYYY (eg 2009)</td>
</tr>
<tr>
<td>The authors don’t state when</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. If an elearning intervention is being studied, does it have a formal name?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (copy the name from the article)</td>
</tr>
<tr>
<td>No it clearly doesn’t have a name</td>
</tr>
<tr>
<td>I can’t tell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Was there a person or organisation providing the elearning intervention?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (please state)</td>
</tr>
<tr>
<td>It’s not clear who was providing the elearning intervention</td>
</tr>
<tr>
<td>There was no intervention provided as this was a survey of attitudes etc to elearning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8. Was special training given to people providing the elearning intervention?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (briefly, what?)</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Not applicable eg this was a survey or the training was delivered by the people or organisation who developed it</td>
</tr>
<tr>
<td>I can’t tell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. Is the aim of the elearning intervention stated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (what was it - copy and paste from article if possible)</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>I can’t tell</td>
</tr>
<tr>
<td>Not applicable as this is a retrospective survey</td>
</tr>
</tbody>
</table>
### 10. What is the curriculum area (ie topic of the elearning), if any? Please copy and paste from the article or briefly summarise the topic.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
</table>

### 11. What was the duration of the e-learning intervention? ie how long is the elearning intervention designed to take to complete (not actual completion duration)

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
</table>

- Not stated
- Not applicable
- Unclear
- Clearly stated (please specify)

### 12. What was the elearning intervention or process?

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
</table>

- Online powerpoint or other modules
- Online live lecture (synchronous), may have been recorded for later viewing but watched live as the intervention
- Online recorded lecture (not live, asynchronous)
- Online reading materials
- Online virtual patient
- Computer based program on a hard drive
- CD rom for individual use
- Something else clearly described (what was it?)
- It’s not described

### 13. How was the elearning intervention delivered?

<table>
<thead>
<tr>
<th>Delivery</th>
<th>Description</th>
</tr>
</thead>
</table>

- Fully online as the only educational intervention
- Online as part of a blended learning approach (eg online combined with paper or lecture programs)
- Computer based (CD rom or hard drive) as part of a blended approach
- Solely computer based (CD rom or hard drive)
- Another way clearly stated (what was it?)
- It’s not clear
- This was not an intervention study but a survey of elearning attitudes etc

### 14. In what setting was the elearning intervention delivered?

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
</table>

- University core unit
- University elective unit
- Continuing Education program
- Distance learning program (postgraduate)
- Distance learning program (undergraduate)
- Another way, clearly stated (what was it?)
- It doesn’t say

### 15. Is there any other relevant information about the elearning intervention (eg teaching methods, content, other materials) that you wish to add?

- Yes (copy and paste from the article if possible, or briefly summarise)
- No
16. Who were the intervention participants in the study?
   - Pharmacists (how many?)
   - Intern Pharmacists (how many?)
   - Pharmacy Students (how many?)
   - Health professionals as well as one or more of those above (show total n)
   - Other (describe and provide n)

17. If this study included a pre-post-test or follow up period, how many intervention participants completed pre-post-test or follow up?
   - This was not a pre-post test design
   - Pre-test completed by pharmacists (how many?)
   - Pre-test completed by intern pharmacists (how many?)
   - Pre-test completed by pharmacy students (how many?)
   - Post-test completed by pharmacists (how many?)
   - Post-test completed by intern pharmacists (how many?)
   - Post-test completed by pharmacy students (how many?)
   - Follow up completed by pharmacists (how many and when?)
   - Follow up completed by intern pharmacists (how many and when?)
   - Follow up completed by pharmacy students (how many and when?)
   - No pre-test was conducted
   - No post-test was conducted
   - It's not clear
   - Something else (what?)

18. Who were the control participants in the study?
   - There was no control group
   - Pharmacists
   - Intern Pharmacists
   - Pharmacy Students
   - Other (who were they?)

19. What was the control group intervention? You may select more than one answer if there was more than one control group.
   - No control group
   - Didactic face to face lecture on the same topic as elearning group
   - Paper based intervention (eg worksheets, books) on the same topic as elearning group
   - No education intervention on the same topic as elearning group
   - Live workshop (in person, not online) on the same topic as elearning group
   - Something else clearly stated (what was it?)
   - It's not clearly stated
20. If this study included a pre-post-test or follow up period, how many control participants completed pre-post-test or follow up?

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>No control group</td>
</tr>
<tr>
<td>This was not a pre-post test design</td>
</tr>
<tr>
<td>Pre-test completed by controls (how many?)</td>
</tr>
<tr>
<td>Post-test completed by controls (how many?)</td>
</tr>
<tr>
<td>Follow up completed by controls (how many and when?)</td>
</tr>
<tr>
<td>No pre-test</td>
</tr>
<tr>
<td>No post-test</td>
</tr>
<tr>
<td>No follow up</td>
</tr>
<tr>
<td>It’s not clear</td>
</tr>
</tbody>
</table>

21. Is there any other useful information about the study participants that you wish to present?

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (Please specify)</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
### 5. Study Design

1. What is the design of this study?
   - Randomised Controlled Trial
   - Controlled Study (no random allocation)
   - Single group pre-post test
   - Single group post-test only
   - Multi group pre-post test (how many groups?)
   - Multi group post-test only (how many groups?)
   - Statistical Survey
   - Interrupted Time Series Study (eg pretest, intervention, posttest, then follow up test/s)
   - Review paper
   - Something else clearly stated (what?)
   - I can't tell

2. Please select the study timing:
   - If the study examines one or more samples but each at only one point in time it is cross-sectional
   - If the study examines the same samples but as they have changed over time, it is a retrospective, provided that the interest is in starting at one timepoint and looking backwards over time
   - If the study examines the same samples as they have changed over time and if data are collected forward over time, it is prospective provided that the interest is in starting at one timepoint and looking forward in time
   - Cross-sectional
   - Retrospective
   - Prospective
   - Unclear (state if possible)

3. Is the sampling frame from which the participants are chosen stated? (eg all pharmacists undertaking CE programs across a geographical state, all students within a certain university course)
   - Yes (what was it?)
   - No it is not stated
   - It's not clear or I can't tell

4. How were participants recruited?
   - Face-to-face invitation
   - Letter of invitation
   - E-mail
   - Not recruited as this was an audit
   - At the point of participation in the elearning intervention
   - Some other way (what was it?)
   - Unclear/I can't tell
   - Definitely not stated

5. Were incentives provided to recruit people to the study (not to undertake the elearning)?
   - Yes (what were they?)
   - No
   - Unclear/I can't tell
6. Did the study obtain ethics approval?
   - Yes and it was stated
   - No because it was not necessary as the study was an audit or low risk (this should be stated, not implied)
   - It is not clearly stated or I can't tell
   - Ethics approval was not obtained

7. How does the study select people, or groups of people (from the sampling frame)?
   - All members of the sampling frame were included
   - Random selection (eg using a random numbers generator)
   - Systematic selection (eg every 3rd person was chosen)
   - Convenience sample (anyone who agreed to participate)
   - Another way clearly stated (what was it?)
   - Method not stated
   - It's unclear or I can't tell
   - There was no selection as this was an audit

8. How were the intervention and control participants allocated?
   - Random allocation to intervention or control group
   - Non random allocation to intervention or control group
   - There was no control group
   - There was no allocation as this was a survey or audit

9. Was there a concealment (blinding) of which group that subjects were assigned to (i.e. the intervention or control)?
   - Yes the researchers were blinded to the study group
   - No the researchers were not blinded to the study group
   - I can't tell

10. Were those carrying out the measurement of outcome different to those carrying out the intervention?
    - Yes
    - No
    - Unclear

11. Do the authors describe a power and sample size calculation?
    - Yes clearly
    - Definitely not
    - It's not clear or I can't tell

12. Do the authors give a rationale to support the methods used in the study (i.e a rationale for sampling, data collection or analysis?)
    - Yes (briefly describe or copy and paste from the article)
    - No
    - Unclear/can't tell

13. Do authors report how the study was funded?
    - Yes, clearly (how was it funded?)
    - Unclear/ I can't tell/not stated
### 4. Outcomes and data collection methods

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Which of the following elearning effectiveness measures (outcomes)</td>
<td>Measured knowledge, Practice change, Patient outcome, Course satisfaction or acceptability, Participation rates (NOT participation in this study, but participation in elearning. This relates to audit or survey methods), Self-perceived knowledge/ability, Something else clearly described (what?), It's unclear/I can't tell</td>
</tr>
<tr>
<td>2. When were the measurements of the variable(s) used as outcome measures made, in relation to the elearning intervention?</td>
<td>Before and immediately after (pretest/posttest), Only before, Only immediately after, At follow up (state when this was), Another time clearly stated (what was it?), It's not clear/I can't tell</td>
</tr>
<tr>
<td>3. How was the data collected?</td>
<td>Curriculum-based assessment, One-to-one interview (face to face or by phone), Self-completion questionnaire, Self-completion report or diary, Examinations, Practice-based test, Hypothetical scenario including vignettes, Secondary data such as publicly available statistics, Other documentation clearly stated (what was it?), Attendance records, Unclear/not stated</td>
</tr>
<tr>
<td>4. Were any validated tools used?</td>
<td>Yes (what were they?), No, Unclear (why?)</td>
</tr>
<tr>
<td>5. Do the authors describe any ways they have addressed the validity or trustworthiness of their data collection tools/methods?</td>
<td>Yes (how?), No, not described, Unclear</td>
</tr>
</tbody>
</table>
6. Do the authors describe any ways they addressed the repeatability or reliability of their data collection tools/methods?
- e.g. test-re-test methods
  - Yes (how?)
  - No, not described
  - Unclear

7. Where were the data collected?
- Educational Institution (specify)
- Online
- Other setting (specify)
- From existing records (i.e. audit) - (where?)
- Not stated/unclear

8. Do the authors report any unintended or unexpected outcomes (outcomes not determined a priori)?
- Yes (what were they?)
- No

9. Which statistical methods were used in the analysis?
- Paired t-test
- Independent t-test
- Chi-square test
- ANOVA
- Statistical modelling (e.g. linear or logistic regression)
- Another clearly described method (please state)
- No statistical analysis conducted

10. Do the authors describe strategies used in the analysis to control for bias from confounding variables?
- Yes (what were they?)
- No strategies described
- Unclear/I can't tell

11. Do the authors describe any ways that they have addressed the validity of data analysis?
- e.g. have any statistical assumptions necessary for analysis been met?
  - Yes (how have they done this?)
  - No
  - Unclear/I can't tell
### G. Outcomes: Reaction (attitudes and perceptions)

1. Does this paper measure change in attitudes or perceptions as a result of the elearning intervention?
   - Yes
   - No

2. What changes in attitude or perception were measured?
   - Satisfaction with the elearning intervention
   - Satisfaction with using e-technology (not the intervention)
   - Self perceived knowledge or skills
   - Acceptability (eg through participation rates in the elearning intervention)
   - Something else clearly described (what was it?)
   - Change in attitude or perception was NOT measured

3. How were these changes measured?
   - Likert scales
   - Participation rates in the INTERVENTION (not participation in the study)
   - Survey of attitudes about the elearning intervention
   - Survey of attitudes about the technology used (NOT the elearning intervention)
   - Some other way clearly described (what was it? Describe, copy and paste; be brief)
   - It’s not clearly described
   - Change in attitude or perception was NOT measured

4. On whom were the changes measured?
   - Pharmacists
   - Intern Pharmacists
   - Pharmacy Students
   - A control group (who were they?)
   - Change in attitude or perception was NOT measured

5. When were these measurements taken?
   - Immediately pre and post intervention
   - Pre intervention only
   - Post intervention only
   - Pre, post and at follow up (when was follow up?)
   - Another way (what was it?)
   - Unclear (why?)
   - Change in attitude or perception was NOT measured

6. How are the results (regarding change in attitudes or perceptions as a result of the elearning program) presented?
   - Please give actual results, or if too complex, table numbers and page numbers in the article. Please copy and paste text from the results section if relevant.
   - If change in attitudes or perceptions was NOT measured, write NA.
## H. Outcomes: Learning (Knowledge and Skills)

<table>
<thead>
<tr>
<th>Question</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does this paper measure change in knowledge or skills as a result of the elearning intervention?</td>
<td>Yes  No</td>
</tr>
<tr>
<td>2. What changes in knowledge were measured? Knowledge change relates to the acquisition of concepts, procedures and principles.</td>
<td>Knowledge gain or loss associated with the elearning intervention  Something else clearly described (what was it?)  Change in knowledge was NOT measured</td>
</tr>
<tr>
<td></td>
<td>Study specific pre and post knowledge tests</td>
</tr>
<tr>
<td></td>
<td>Study specific pre and post knowledge tests WITH follow up test/s</td>
</tr>
<tr>
<td></td>
<td>Usual curriculum knowledge test or exam</td>
</tr>
<tr>
<td></td>
<td>Some other way clearly described (what was it? Describe, copy and paste; be brief)</td>
</tr>
<tr>
<td></td>
<td>It's not clearly described</td>
</tr>
<tr>
<td></td>
<td>Change in knowledge was NOT measured</td>
</tr>
<tr>
<td>3. How were these knowledge changes measured?</td>
<td></td>
</tr>
<tr>
<td>4. On whom were the knowledge changes measured?</td>
<td>Pharmacists                                        Intern Pharmacists                                   Pharmacy Students</td>
</tr>
<tr>
<td></td>
<td>A control group (who were they?)</td>
</tr>
<tr>
<td></td>
<td>Change in knowledge was NOT measured</td>
</tr>
<tr>
<td>5. When were these knowledge change measurements taken?</td>
<td>Immediately pre and post intervention</td>
</tr>
<tr>
<td></td>
<td>Pre intervention only</td>
</tr>
<tr>
<td></td>
<td>Post intervention only</td>
</tr>
<tr>
<td></td>
<td>Pre, post and at follow up (when was follow up?)</td>
</tr>
<tr>
<td></td>
<td>Another way (what was it?)</td>
</tr>
<tr>
<td></td>
<td>Unclear (why?)</td>
</tr>
<tr>
<td></td>
<td>Change in knowledge was NOT measured</td>
</tr>
<tr>
<td>6. How are the results (regarding change in knowledge as a result of the elearning program) presented?</td>
<td>Actual scores                                                                                     Percentage scores</td>
</tr>
<tr>
<td></td>
<td>Another way (what?)</td>
</tr>
<tr>
<td></td>
<td>Not clearly described (why?)</td>
</tr>
<tr>
<td></td>
<td>Change in knowledge was NOT measured</td>
</tr>
</tbody>
</table>
7. Please give any other knowledge relevant actual results, or if too complex, table numbers and page numbers in the article. Please copy and paste text from the results section if relevant. If you have nothing to add here write NA.

8. What changes in skills were measured? Skills change relates to the acquisition of thinking/problem solving, psychomotor and social skills.
   - Thinking/problem solving ability as a result of the elearning intervention
   - Something else clearly described (what was it?)
   - Change in skills was NOT measured

9. How were these skills changes measured? Please describe or copy and paste from article. If skills change was not measured, write NA.

10. On whom were the skills changes measured?
   - Pharmacists
   - Intern Pharmacists
   - Pharmacy Students
   - A control group (who were they?)
   - Change in skills was NOT measured

11. When were these skills change measurements taken?
   - Immediately pre and post intervention
   - Pre intervention only
   - Post intervention only
   - Pre, post and at follow up (when was follow up?)
   - Another way (what was it?)
   - Unclear (why?)
   - Change in skills was NOT measured

12. How are the results (regarding change in skills as a result of the elearning program) presented? Please describe or copy and paste from article. If skills change was not measured, write NA.

13. Please give any other skills relevant actual results, or if too complex, table numbers and page numbers in the article. Please copy and paste text from the results section if relevant. If you have nothing to add here write NA.
### I: Outcomes: Behaviour and Results (applicable to the intervention)

1. Does this paper measure change in behaviour, organisational practice or benefits to patients as a result of the elearning intervention?

   Select the changes that apply, relevant to their descriptions in the answer text.
   - Individual behavioural actual change (transfer of what was learnt to the workplace, ie practice change)
   - Individual behavioural willingness change (willingness to apply new knowledge and skills, ie intended change)
   - Group program

   None of the above were measured

2. How were these identified changes measured? Please describe or copy and paste from article. If no changes were measured, write NA.

3. On whom were these identified changes measured?
   - Pharmacists
   - Intern Pharmacists
   - Pharmacy Students
   - A control group (who were they?)

   These changes were NOT measured

4. Please describe when these identified change measurements were taken. Copy and paste from the article if relevant. If no measurements of this type were taken, write NA.

5. How are the results (regarding change in these identified behaviours and practices as a result of the elearning program) presented? Please describe or copy and paste from article. If change was not measured, write NA.

6. Please give any other behavioural, organisational or patient outcome relevant actual results, or if too complex, table numbers and page numbers in the article. Please copy and paste text from the results section if relevant. If you have nothing to add here write NA.
## Appendices

### 4. Overall impressions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the authors main conclusions about the findings of the study?</td>
<td></td>
</tr>
<tr>
<td>Please give details and refer to page numbers in the article where relevant. You may copy and paste text from the article here but please be brief.</td>
<td></td>
</tr>
<tr>
<td>2. By working through the answers to the questions above you should have a thorough understanding of this article. Based on your answers, what is your impression of the conclusions made by the authors?</td>
<td></td>
</tr>
<tr>
<td>1. No clear conclusions can be drawn; not significant</td>
<td></td>
</tr>
<tr>
<td>2. Results ambiguous, but there appears to be a trend</td>
<td></td>
</tr>
<tr>
<td>3. Conclusions can probably be based on the results</td>
<td></td>
</tr>
<tr>
<td>4. Results are clear and very likely to be true</td>
<td></td>
</tr>
<tr>
<td>5. Results are unequivocal</td>
<td></td>
</tr>
<tr>
<td>3. Are there ethical concerns about the way the study was done?</td>
<td></td>
</tr>
<tr>
<td>Consider consent, funding, privacy, etc.</td>
<td></td>
</tr>
<tr>
<td>Yes (why?)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>4. To what extent are the research design and methods employed able to rule out any other sources of error/bias which would lead to alternative explanations for the findings of the study?</td>
<td></td>
</tr>
<tr>
<td>e.g. (1) Was the process by which participants were allocated to, or otherwise received the e-learning intervention, concealed and not predictable in advance? If not, were sufficient substitute procedures employed with adequate rigour to rule out any alternative explanations of the findings which arise as a result?</td>
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<tr>
<td>e.g. (2) Was the attrition rate low and, if applicable, similar between intervention and control groups?</td>
<td></td>
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<tr>
<td>A lot</td>
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<tr>
<td>A little</td>
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<tr>
<td>Not at all</td>
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<tr>
<td>5. In light of your answers above, do your opinions differ from the authors’ opinions over the findings or conclusions of the study?</td>
<td></td>
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<tr>
<td>Yes (Please state what any difference is)</td>
<td></td>
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<tr>
<td>No</td>
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</tbody>
</table>
Appendix 3 – Anaphylaxis Training Pharmacist Assessment Tool (AT-PAsT): Pre-training test.

**IMAP Study: Comparing Lectures with Online Learning**

**Pre-CE Quiz**

**Question 1**
A patient having an allergic reaction comes into your pharmacy. The only symptoms they present with are hives on their body. What action would you take? *(please circle)*

- a) Give them loratadine 10mg orally and tell them if they have any signs of anaphylaxis they must call an ambulance
- b) Give them adrenaline using an adrenaline autoinjector and call an ambulance
- c) Give them hydrocortisone 1% cream and tell them if they have signs of anaphylaxis they must call an ambulance
- d) All of the above

**Question 2**
A patient comes into your pharmacy with a prescription for Anapen to replace their expired device. You currently only have EpiPen in stock. Do you… *(please circle)*

- a) Dispense the EpiPen as you are aware that Anapen and EpiPen are brand substitutable
- b) Ask them if they would prefer the EpiPen to save them coming back to collect the Anapen
- c) Inform them that you are out of stock of the Anapen and they will have to come back to collect their Anapen when the stock arrives or obtain it from a different pharmacy
- d) Hold the prescription on file for them until you have Anapen in stock and recommend they buy an EpiPen over the counter in the meantime
Question 3
A patient with a history of asthma presents to your pharmacy with bronchoconstriction after eating shellfish. You are unsure if they are experiencing asthma or anaphylaxis. What action should you take? (please circle)

- a) Give adrenaline autoinjector first, then give asthma reliever medication
- b) Give asthma reliever medication first, then give adrenaline autoinjector
- c) Give adrenaline autoinjector
- d) Give asthma reliever medication and call an ambulance

Question 4
A patient has been stung by a bee and is vomiting and complaining of abdominal pain. Are these symptoms of anaphylaxis? (please tick)

☐ Yes ☐ No

The following three questions relate to device usage and require pharmacists to correctly order the four steps for administering the devices.

Question 5
How to use new look EpiPen
(please draw a line linking the correct order for each of the steps)

Step 1

Step 2

Step 3

Step 4

- REMOVE EpiPen, massage injection site for 10 seconds.
- Form fist around EpiPen and Pull OFF BLUE SAFETY RELEASE.
- PLACE ORANGE END against outer mid-thigh (with or without clothing).
- PUSH DOWN HARD until a click is heard or felt and hold in place for 10 seconds.
Question 6
How to use Anapen
(please draw a line linking the correct order for each of the steps)

Step 1
PULL OFF GREY SAFETY CAP from red button.

Step 2
PLACE NEEDLE END FIRMLY against outer mid-thigh at 90° angle (with or without clothing).

Step 3
PRESS RED BUTTON so it clicks and hold for 10 seconds. REMOVE Anapen and DO NOT touch needle. Massage injection site for 10 seconds.

Step 4
PULL OFF BLACK NEEDLE SHIELD.

Question 7
How to use original EpiPen
(please draw a line linking the correct order for each of the steps)

Step 1
REMOVE EpiPen and DO NOT touch needle. Massage injection site for 10 seconds.

Step 2
Form flat around EpiPen and PULL OFF GREY SAFETY CAP

Step 3
PLACE BLACK END against outer mid-thigh (with or without clothing).

Step 4
PUSH DOWN HARD until a click is heard or felt and hold in place for 10 seconds.
**Question 8**
Which factors increase the risk of fatal anaphylaxis? *(please circle)*
- a) Asthma, delayed adrenaline administration and upright posture
- b) Asthma, upright posture, young child
- c) Large local reactions to bee stings
- d) Delayed administration of antihistamine

**Question 9**
With regards to adrenaline, which of the following statements is FALSE?
- a) It is equally effective when administered by IM or SC injection
- b) Repeat doses may be required as maximum effects last only 15-20 minutes
- c) It inhibits the release of inflammatory mediators
- d) It is well tolerated in children and adults

**Question 10**
Which of the following components are included on the ASCIA Action Plan for Anaphylaxis? *(please circle)*
- a) Action for allergic reaction with a picture of how to use an adrenaline autoinjector
- b) Signs of anaphylaxis
- c) Symptoms of mild to moderate allergic reaction
- d) All of the above are correct
- e) Answers (a) and (b) are correct

**Question 11**
At what stage should a child’s prescription change from a junior dose adrenaline autoinjector (0.15mg) to a higher dose adrenaline autoinjector (0.30mg)?
- a) When the child is >20kg in weight
- b) When the child is >30kg in weight
- c) When the child is aged 8 years
- d) When the child is aged 12 years

**Question 12**
A man presents to your pharmacy for advice 30 minutes after successfully administering his adrenaline autoinjector for insect sting anaphylaxis. The man appears to have fully recovered but wants to know if he still needs to go to hospital. Do you immediately refer him to the nearest emergency department?

☐ Yes ☐ No
Appendix 3 – Anaphylaxis Training Pharmacist Assessment Tool (AT-PAsT): Post-training test.

IMAP Study: Comparing Lectures with Online Learning

Post-CE Quiz

Question 1
A man presents to your pharmacy for advice 30 minutes after successfully administering his adrenaline autoinjector for insect sting anaphylaxis. The man appears to have fully recovered but wants to know if he still needs to go to hospital. Do you immediately refer him to the nearest emergency department?

☐ Yes ☐ No

Question 2
Which of the following components are included on the ASCIA Action Plan for Anaphylaxis? (please circle)

f) Action for allergic reaction with a picture of how to use an adrenaline autoinjector
g) Signs of anaphylaxis
h) Symptoms of mild to moderate allergic reaction
i) All of the above are correct
j) Answers (a) and (b) are correct

Question 3
At what stage should a child’s prescription change from a junior dose adrenaline autoinjector (0.15mg) to a higher dose adrenaline autoinjector (0.30mg)?

e) When the child is aged 8 years
f) When the child is aged 12 years
g) When the child is >30kg in weight
h) When the child is >20kg in weight
Question 4
Which factors increase the risk of fatal anaphylaxis? (please circle)
   e) Asthma, upright posture, young child
   f) Delayed administration of antihistamine
   g) Asthma, delayed adrenaline administration and upright posture
   h) Large local reactions to bee stings

Question 5
A patient having an allergic reaction comes into your pharmacy. The only symptoms they present with are hives on their body. What action would you take? (please circle)
   e) Give them hydrocortisone 1% cream and tell them if they have signs of anaphylaxis they must call an ambulance
   f) Give them adrenaline using an adrenaline autoinjector and call an ambulance
   g) Give them loratadine 10mg orally and tell them if they have any signs of anaphylaxis they must call an ambulance
   h) All of the above

The following three questions relate to device usage and require pharmacists to correctly order the four steps for administering the devices.

Question 6
How to use original EpiPen
(please draw a line linking the correct order for each of the steps)
Question 7
How to use Anapen
*(please draw a line linking the correct order for each of the steps)*

Step 1
- PRESS RED BUTTON so it clicks and hold for 10 seconds. REMOVE Anapen and DO NOT touch needle. Massage injection site for 10 seconds.

Step 2
- PLACE NEEDLE END FIRMLY against outer mid-thigh at 90° angle (with or without clothing).

Step 3
- PULL OFF BLACK NEEDLE SHIELD.

Step 4
- PULL OFF GREY SAFETY CAP from red button.

Question 8
How to use new look EpiPen
*(please draw a line linking the correct order for each of the steps)*

Step 1
- PUSH DOWN HARD until a click is heard or felt and hold in place for 10 seconds.

Step 2
- PLACE ORANGE END against outer mid-thigh (with or without clothing).

Step 3
- Form felt around EpiPen and PULL OFF BLUE SAFETY RELEASE.

Step 4
- REMOVE EpiPen. massage injection site for 10 seconds.
Question 9
A patient comes into your pharmacy with a prescription for Anapen to replace their expired device. You currently only have EpiPen in stock. Do you… *(please circle)*

- e) Hold the prescription on file for them until you have Anapen in stock and recommend they buy an EpiPen over the counter in the meantime
- f) Ask them if they would prefer the EpiPen to save them coming back to collect the Anapen
- g) Inform them that you are out of stock of the Anapen and they will have to come back to collect their Anapen when the stock arrives or obtain it from a different pharmacy
- h) Dispense the EpiPen as you are aware that Anapen and EpiPen are brand substitutable

Question 10
With regards to adrenaline, which of the following statements is FALSE?
- e) Repeat doses may be required as maximum effects last only 15-20 minutes
- f) It is well tolerated in children and adults
- g) It is equally effective when administered by IM or SC injection
- h) It inhibits the release of inflammatory mediators

Question 11
A patient with a history of asthma presents to your pharmacy with bronchoconstriction after eating shellfish. You are unsure if they are experiencing asthma or anaphylaxis. What action should you take? *(please circle)*

- e) Give adrenaline autoinjector
- f) Give asthma reliever medication and call an ambulance
- g) Give asthma reliever medication first, then give adrenaline autoinjector
- h) Give adrenaline autoinjector first, then give asthma reliever medication

Question 12
A patient has been stung by a bee and is vomiting and complaining of abdominal pain. Are these symptoms of anaphylaxis? *(please tick)*

☐ Yes    ☐ No
Appendix 3 – Anaphylaxis Training Pharmacist Assessment Tool (AT-PAsT): 3-month online test.

**Question 1:** Which of the following components are included on the ASCIA Action Plan for Anaphylaxis?
- a) Symptoms of mild to moderate allergic reaction
- b) Action for allergic reaction with a picture of how to use an adrenaline autoinjector
- c) Signs of anaphylaxis
- d) All of the above are correct
- e) Answers (b) and (c) are correct

**Question 2:** At what stage should a child’s prescription change from a junior dose adrenaline autoinjector (0.15mg) to a higher dose adrenaline autoinjector (0.30mg)?
- a) When the child is aged 8 years
- b) When the child is >20kg in weight
- c) When the child is aged 12 years
- d) When the child is >30kg in weight

**Question 3:** A man presents to your pharmacy for advice 30 minutes after successfully administering his adrenaline autoinjector for insect sting anaphylaxis. The man appears to have fully recovered but wants to know if he still needs to go to hospital. Do you immediately refer him to the nearest emergency department?
- Yes
- No

**Question 4:** With regards to adrenaline, which ONE of the following statements is FALSE?
- a) It inhibits the release of inflammatory mediators
- b) Repeat doses may be required as maximum effects last only 15-20 minutes
- c) It is well tolerated in children and adults
- d) It is equally effective when administered by IM or SC injection

**Question 5:** A patient has been stung by a bee and is vomiting and complaining of abdominal pain. Are these symptoms of anaphylaxis?
- No
- Yes
Appendices

Question 6 - How to use original EpiPen. Drag and drop the images to order the steps for original EpiPen administration, with 1 being the first step and 4 being the last step.

- PLACE BLACK END against outer mid-thigh (with or without clothing).
- PUSH DOWN HARD until a click is heard or felt and hold in place for 10 seconds.
- Form fist around EpiPen and PULL OFF GREY SAFETY CAP.
- REMOVE EpiPen and DO NOT touch needle. Massage injection site for 10 seconds.

Question 7 - How to use Anapen. Drag and drop the images to order the steps for Anapen administration, with 1 being the first step and 4 being the last step.

- PULL OFF GREY SAFETY CAP from red button.
- PLACE NEEDLE END FIRMLY against outer mid-thigh at 90° angle (with or without clothing).
- PULL OFF BLACK NEEDLE SHIELD.
- PRESS RED BUTTON so it clicks and hold for 10 seconds. REMOVE Anapen and DO NOT touch needle. Massage injection site for 10 seconds.

Question 8 - How to use new look EpiPen. Drag and drop the images to order the steps for new look EpiPen administration, with 1 being the first step and 4 being the last step.

- Form fist around EpiPen and PULL OFF BLUE SAFETY RELEASE.
- PUSH DOWN HARD until a click is heard or felt and hold in place for 10 seconds.
- PLACE ORANGE END against outer mid-thigh (with or without clothing).
- REMOVE EpiPen. Massage injection site for 10 seconds.
Appendices

Question 9: A patient comes into your pharmacy with a prescription for Anapen to replace their expired device. You currently only have EpiPen in stock. Do you...

- a) Inform them that you are out of stock of the Anapen and they will have to come back to collect their Anapen when the stock arrives or obtain it from a different pharmacy
- b) Hold the prescription on file for them until you have Anapen in stock and recommend they buy an EpiPen over the counter in the meantime
- c) Ask them if they would prefer the EpiPen to save them coming back to collect the Anapen
- d) Dispense the EpiPen as you are aware that Anapen and EpiPen are brand substitutable

Question 10: Which factors increase the risk of fatal anaphylaxis?

- a) Large local reactions to bee stings
- b) Asthma, upright posture, young child
- c) Delayed administration of antihistamine
- d) Asthma, delayed adrenaline administration and upright posture

Question 11: A patient with a history of asthma presents to your pharmacy with bronchoconstriction after eating shellfish. You are unsure if they are experiencing asthma or anaphylaxis. What action should you take?

- a) Give adrenaline autoinjector
- b) Give asthma reliever medication and call an ambulance
- c) Give asthma reliever medication first, then give adrenaline autoinjector
- d) Give adrenaline autoinjector first, then give asthma reliever medication

Question 12: A patient having an allergic reaction comes into your pharmacy. The only symptoms they present with are hives on their body. What action would you take?

- a) Give them adrenaline using an adrenaline autoinjector and call an ambulance
- b) Give them hydrocortisone 1% cream and tell them if they have signs of anaphylaxis they must call an ambulance
- c) Give them loratadine 10mg orally and tell them if they have any signs of anaphylaxis they must call an ambulance
- d) All of the above
Appendix 3 – Anaphylaxis Training Pharmacist Assessment Tool (AT-PAsT): 7-month online test.

With regards to adrenaline, which of the following statements is FALSE?

- a) It is well tolerated in children and adults
- b) It inhibits the release of inflammatory mediators
- c) It is equally effective when administered by IM or SC injection
- d) Repeat doses may be required as maximum effects last only 15-20 minutes

Which of the following components are included on the ASCIA Action Plan for Anaphylaxis?

- a) Symptoms of mild to moderate allergic reaction
- b) Signs of anaphylaxis
- c) Action for allergic reaction with a picture of how to use an adrenaline autoinjector
- d) All of the above are correct
- e) Answers (b) and (c) are correct

A patient with a history of asthma presents to your pharmacy with bronchoconstriction after eating shellfish. You are unsure if they are experiencing asthma or anaphylaxis. What action should you take?

- a) Give asthma reliever medication and call an ambulance
- b) Give adrenaline autoinjector first, then give asthma reliever medication
- c) Give adrenaline autoinjector
- d) Give asthma reliever medication first, then give adrenaline autoinjector

A patient having an allergic reaction comes into your pharmacy. The only symptoms they present with are hives on their body. What action would you take?

- a) Give them adrenaline using an adrenaline autoinjector and call an ambulance
- b) Give them loratadine 10mg orally and tell them if they have any signs of anaphylaxis they must call an ambulance
- c) Give them hydrocortisone 1% cream and tell them if they have signs of anaphylaxis they must call an ambulance
- d) All of the above
Appendices

A patient comes into your pharmacy with a prescription for Anapen to replace their expired device. You currently only have EpiPen in stock. Do you...
- a) Dispense the EpiPen as you are aware that Anapen and EpiPen are brand substitutable
- b) Hold the prescription on file for them until you have Anapen in stock and recommend they buy an EpiPen over the counter in the meantime
- c) Ask them if they would prefer the EpiPen to save them coming back to collect the Anapen
- d) Inform them that you are out of stock of the Anapen and they will have to come back to collect their Anapen when the stock arrives or obtain it from a different pharmacy

At what stage should a child’s prescription change from a junior dose adrenaline autoinjector (0.15mg) to a higher dose adrenaline autoinjector (0.30mg)?
- a) When the child is aged 8 years
- b) When the child is aged 12 years
- c) When the child is >20kg in weight
- d) When the child is >30kg in weight

A patient has been stung by a bee and is vomiting and complaining of abdominal pain. Are these symptoms of anaphylaxis?
- Yes
- No

Which factors increase the risk of fatal anaphylaxis?
- a) Asthma, upright posture, young child
- b) Large local reactions to bee stings
- c) Asthma, delayed adrenaline administration and upright posture
- d) Delayed administration of antihistamine

A man presents to your pharmacy for advice 30 minutes after successfully administering his adrenaline autoinjector for insect sting anaphylaxis. The man appears to have fully recovered but wants to know if he still needs to go to hospital. Do you immediately refer him to the nearest emergency department?
- Yes
- No
Appendices

How to use original EpiPen
(please place diagrams into correct order)
- REMOVE EpiPen and DO NOT touch needle.
  - Massage injection site for 10 seconds.

- Firmly around EpiPen and PULL OFF GREY
  - SAFETY GAP.

- PUSH DOWN HARD until a click is heard or felt
  - and hold in place for 10 seconds.

- PLACE BLACK END against outer mid-thigh (with
  - or without clothing).

How to use new look EpiPen
(please place diagrams into correct order)
- PUSH DOWN HARD until a click is heard or felt
  - and hold in place for 10 seconds.

- Firmly around EpiPen and PULL OFF BLUE
  - SAFETY RELEASE.

- PLACE ORANGE END against outer mid-thigh (with
  - or without clothing).

- REMOVE EpiPen, massage injection site for 10
  - seconds.

How to use Anapen
(please place diagrams into correct order)
- PULL OFF GREY SAFETY GAP from red button.

- PULL OFF BLACK NEEDLE SHIELD.

- PLACE NEEDLE END FIRMLY against outer
  - mid-thigh at 90° angle (with or without clothing).

- PRESS RED BUTTON so it clicks and hold for 10
  - seconds. REMOVE Anapen and DO NOT touch needle
  - Massage injection site for 10 seconds.
Appendix 4 – Simulated patient scenario.

Pharmacists’ Response to Anaphylaxis in the Community (PRAC) STUDY SCENARIO:

Scenario - Background:

Patient presenting points:
Request to speak to the pharmacist: “Could I please speak with the pharmacist?” If the pharmacy assistant is reluctant to get the pharmacist, tell them you want the pharmacist to give you some advice. You are prepared to wait.
Patient was taken by ambulance to SCGH last week with first episode of anaphylaxis. Has two EpiPens (or Anapens) but does not know how to use them.
Patient is confused and uncertain about what they should do if they have another episode of anaphylaxis.

Patient history (if needed):
1. Mild occasional eczema since childhood.
2. No previously known allergies. Now suspected prawn allergy.
3. No other medications.

History of anaphylaxis event:
Was having dinner at a friend’s house last week, developed coughing and difficulty breathing after eating prawns. Coughing did not improve and then the patient started to develop hives on face and chest, with breathing becoming increasingly difficult.
Friend called the ambulance. Taken to SCGH, spent the night in ED.

EpiPen provision:
After discharge the patient’s relative (Mum, Dad, spouse, sibling – be consistent in whom you choose) collected two EpiPens/Anapens (patient does not know where from) and gave them to the patient at home. The patient has not had any training in the use of the pens and does not know how to use them. They have thrown away the boxes the devices came in.

Anaphylaxis event follow up:
The patient will be seeing a ‘specialist allergy doctor’ in two weeks’ time.
The doctor at SCGH told the patient their anaphylaxis might have been caused by the prawns, but they won’t know until after the allergy specialist has ‘done some tests’ to confirm this.
Someone at SCGH “mentioned antihistamines”, but the patient has not taken an antihistamine before and does not know if they should use an antihistamine.

Scenario responses are on the following page. Questions other than those listed in the scenario should be answered with “I don’t know” or “I can’t remember”.
### Scenario:

“Hi, could I please speak to the pharmacist?
I have recently been given this, [show Anapen/EpiPen], but I don’t know how to use it. Could you show me?”

<table>
<thead>
<tr>
<th>EpiPen/Anapen Questions by Pharmacist</th>
<th>Answers from Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where did you get that from?</td>
<td>My (relative, friend) picked it up for me after I came home from Charlies.</td>
</tr>
<tr>
<td>When did you go to hospital?</td>
<td>Last week</td>
</tr>
<tr>
<td>Why did you go to hospital?</td>
<td>I had a bad allergic reaction and ended up there</td>
</tr>
<tr>
<td>Did you have anaphylaxis last week when you went to hospital?</td>
<td>Yes, that’s what the doctor said</td>
</tr>
<tr>
<td>What happened?</td>
<td>I was having dinner, eating prawns at a friend’s house when I started coughing and found it hard to breathe. Then I got a rash on my face and chest, and the breathing got more and more difficult, so my friends called an ambulance. I went to Charlies and spent the night in ED.</td>
</tr>
</tbody>
</table>

If the pharmacist probes to find out where the EpiPen/Anapen was dispensed

I don’t know, my [Mum, relative, friend] got it for me.

Expect the pharmacist to perform device demonstration now. If device demonstration is refused for any reason, move on to antihistamine advice request.

“I’ve also been told I can use antihistamines. What do you think?”

<table>
<thead>
<tr>
<th>Antihistamine Questions by Pharmacist</th>
<th>Answers from Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who told you that?</td>
<td>Someone at the hospital (the patient can’t remember)</td>
</tr>
<tr>
<td>What were you told to use an antihistamine for?</td>
<td>I can’t remember, but I suppose because of my allergy.</td>
</tr>
<tr>
<td>Have you taken an antihistamine before?</td>
<td>No</td>
</tr>
<tr>
<td>Do you prefer a sedating or non-sedating antihistamine?</td>
<td>Whatever you recommend.</td>
</tr>
<tr>
<td>Do you take any other medicines/herbal/OTC?</td>
<td>No</td>
</tr>
<tr>
<td>Any allergies?</td>
<td>I think I’m allergic to prawns</td>
</tr>
<tr>
<td>Medical conditions?</td>
<td>Mild eczema on and off</td>
</tr>
<tr>
<td>Smoker/Alcohol?</td>
<td>Non-smoker, occasional alcohol</td>
</tr>
<tr>
<td>Have you used anything before for allergy?</td>
<td>Not used anything before for allergy</td>
</tr>
<tr>
<td>Are you seeing an allergy specialist?</td>
<td>Yes, in two weeks’ time</td>
</tr>
<tr>
<td>Do you have an Action Plan?</td>
<td>No</td>
</tr>
</tbody>
</table>

Expect the pharmacist to counsel on antihistamine use. Patient will buy the cheapest pack (or no pack if sale is not recommended) as directed by the pharmacist.
Appendix 5 – Pharmacists’ response to anaphylaxis in the community (PRAC) data collection tool.

<table>
<thead>
<tr>
<th>Column</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Scenario</td>
<td></td>
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<tr>
<td>A</td>
<td>2</td>
<td>New-look EpiPen: Brock</td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>Anapen: Rhoda</td>
</tr>
<tr>
<td>2. Pharmacy Details</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>Street</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Medical Centre</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Shopping Centre</td>
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<tr>
<td></td>
<td>4</td>
<td>Hospital</td>
</tr>
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<td></td>
<td>5</td>
<td>Other (state):</td>
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<td>D</td>
<td></td>
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<tr>
<td></td>
<td>1</td>
<td>Independent</td>
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<td></td>
<td>2</td>
<td>Chain</td>
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<td></td>
<td>3</td>
<td>Discount/warehouse/megamart</td>
</tr>
<tr>
<td>2.2 Location of Pharmacy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
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</tr>
</tbody>
</table>

Enter to: Enter by: Description

PRAC STUDY CODED DATA COLLECTION SHEET

2.2 Location of Pharmacy:

2.3 Type of Pharmacy:

2.4 Numbers of staff and customers in store (estimate)

2.5 Time of day when the visit was performed

3.1 Age (years):

3.2 Gender:

3.3 Did they suspect a simulated patient?

3.4 Was the pharmacist distracted or interrupted during the consultation?

3.5 Did the pharmacist ask or tell another counsellor to handle the consultation, before seeing the patient?

Staff:.................

Customers:.............

0800-1100

1100-1400

1400-1800

After 1800

10-20

21-40

41-50

51-60

50+

1 Male

2 Female

Yes

No

Yes

No

Yes

No

169
### 3.6 Gender of second counsellor:

| M | 1 Male |
| 2 Female |
| 3 No second counsellor |

### 3.7 Age of second counsellor (years):

| N | 1 20-30 |
| 2 31-40 |
| 3 41-50 |
| 4 51-60 |
| 5 60+ |
| 6 No second counsellor |

### 4. Allergy Assessment

**4.1** Did the pharmacist ask: "Do you know what you reacted to?" or "Do you know what caused the allergy/anaphylaxis?" (ie did they identify the allergen?)

| Q | 1 Yes |
| 2 No |

**4.2** Did the pharmacist ask: "Do you have any other allergies?"

| P | 1 Yes |
| 2 No |

**4.3** Did the pharmacist ask: "Are you seeing an allergy specialist/having allergy tests"

| Q | 1 Yes |
| 2 No |

**4.4** Did the pharmacist ask: Do you have an [ASCIA] Action Plan (for Anaphylaxis)?

| R | 1 Yes |
| 2 No |

### 5. Autoinjector Demonstration

**5.1** Did the pharmacist physically demonstrate the use of the EpiPen/Anapen?

| S | 1 Yes |
| 2 No |

**5.2** What did the pharmacist use for the physical demonstration?

| T | 1 Patient’s ‘live’ EpiPen/Anapen |
| 2 Pharmacist’s trainer device |
| 3 Both the patient’s ‘live’ device and a trainer device |
| 4 No physical demonstration performed |

**5.3** Did the pharmacist verbally explain how to use EpiPen/Anapen?

| U | 1 Yes, verbal explanation provided during the physical demonstration |
| 2 Yes, provided verbal explanation **without** physical demonstration |
| 3 No verbal explanation provided |

**5.4** What did the pharmacist use for the verbal explanation?

| V | 1 Patient’s ‘live’ EpiPen/Anapen |
| 2 Written material (Action Plan, CMI) |
| 3 Verbal counselling without any physical prompts |
| 4 Both patient’s ‘live’ EpiPen/Anapen and written material |
| 5 No verbal demonstration performed |

**5.5** Did the pharmacist refer the patient to the instructions on their EpiPen/Anapen?

<p>| W | 1 Yes, during the physical demonstration |
| 2 Yes, during the verbal demonstration |
| 3 Yes, but without any demonstration |
| 4 No, not at any stage |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6 Did the pharmacist consult any references, including reading the</td>
<td></td>
<td>EpiPen/Anapen, before demonstrating or counselling EpiPen/Anapen?</td>
</tr>
<tr>
<td>X 1 Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 No physical demonstration or verbal counselling performed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.7 Did the pharmacist ask another staff member to demonstrate the</td>
<td></td>
<td>Anapen/EpiPen? (after seeing the patient)</td>
</tr>
<tr>
<td>Y 1 Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.8 If the pharmacist asked another staff member to demonstrate the</td>
<td></td>
<td>Anapen/EpiPen, who did they ask?</td>
</tr>
<tr>
<td>Z 1 Second pharmacist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Pharmacy Intern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Pharmacy Assistant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Unsure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Did not ask for another staff member to demonstrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.9 Did the pharmacist provide any anaphylaxis counselling or</td>
<td></td>
<td>information other than device demonstration BEFORE patient asked for</td>
</tr>
<tr>
<td>Antihistamine?</td>
<td></td>
<td>antihistamine?</td>
</tr>
<tr>
<td>AA 1 Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.10 If refused, select the reason for demonstration refusal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB 1 Doctor will show you when you see him/her</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Pharmacy is too busy now, please come back later</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Other (state):.................................................................................. (enter as code 3 only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 No refusal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.11 If the pharmacist used a device other than the patient’s own</td>
<td></td>
<td>demonstration, what did they use?</td>
</tr>
<tr>
<td>AC 1 Original EpiPen trainer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 New look EpiPen trainer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Both Original and New look EpiPen trainers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Anapen trainer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Live EpiPen from pharmacy stock (original or new look)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Live Anapen from pharmacy stock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 No other device used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.12 Device Demonstration: Identify the steps demonstrated for your</td>
<td></td>
<td>device</td>
</tr>
<tr>
<td>Code 1=Demonstrated, 2=Not Demonstrated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CODE DEVICE DEMONSTRATION AS ZERO (0) FOR DEVICES NOT ASSESSED**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD 1</td>
<td>1. Form a fist around EpiPen and remove GREY safety cap</td>
</tr>
<tr>
<td>AE 2</td>
<td>2. Place BLACK end against outer mid thigh (with or without clothing)</td>
</tr>
<tr>
<td>AF 3</td>
<td>3. Push down HARD until a click is heard or felt and hold in place for 10 seconds</td>
</tr>
<tr>
<td>AG 4</td>
<td>4. Remove EpiPen and do not touch needle. Massage injection site for 10 seconds</td>
</tr>
</tbody>
</table>
### Appendices

<table>
<thead>
<tr>
<th>AH</th>
<th>1. Form a fist around New EpiPen and pull off BLUE safety release</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>2. Place ORANGE end against outer mid thigh (with or without clothing)</td>
</tr>
<tr>
<td>AJ</td>
<td>3. Push down HARD until a click is heard or felt and hold in place for 10 seconds</td>
</tr>
</tbody>
</table>

**Code 1=Demonstrated, 2=Not Demonstrated**

**CODE DEVICE DEMONSTRATION AS ZERO (0) FOR DEVICES NOT ASSESSED**

<table>
<thead>
<tr>
<th>AL</th>
<th>1. Pull off BLACK needle shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>2. Pull off GREY safety cap from RED button</td>
</tr>
<tr>
<td>AN</td>
<td>3. Place needle end firmly against outer mid-thigh with or without clothing</td>
</tr>
<tr>
<td>AO</td>
<td>4. Press RED button so it clicks and hold for 10 seconds. Remove Anapen and do not touch needle. Massage injection site for 10 seconds.</td>
</tr>
</tbody>
</table>

#### 5.13 Which of the following errors were made in device demonstration?

**Code 1=Error Made, 2=Error NOT made**

<table>
<thead>
<tr>
<th>AP</th>
<th>Incorrect order for removal of black shield and grey cap (Anapen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ</td>
<td>Removal of safety release caps not stated</td>
</tr>
<tr>
<td>AR</td>
<td>Thumb positioned over the end of EpiPen</td>
</tr>
<tr>
<td>AS</td>
<td>Thumb not used to inject Anapen (Used EpiPen technique)</td>
</tr>
<tr>
<td>AT</td>
<td>Did not say &quot;Massage injection site for 10 seconds&quot;</td>
</tr>
<tr>
<td>AU</td>
<td>Wrong site for injection (eg buttock, arm)</td>
</tr>
<tr>
<td>AV</td>
<td>Incorrect arm technique for EpiPen (wide swinging, 90 degrees)</td>
</tr>
<tr>
<td>AW</td>
<td>Did not say &quot;Push down hard until a click is heard&quot; (or similar)</td>
</tr>
<tr>
<td>AX</td>
<td>Did not say &quot;Hold for 10 seconds&quot; after injection (or similar)</td>
</tr>
<tr>
<td>AY</td>
<td>Did not say &quot;Don’t touch needle&quot; (Original EpiPen and Anapen) after removal of EpiPen/Anapen (or similar)</td>
</tr>
</tbody>
</table>

#### 8.1 Did the pharmacist counsel on the signs of anaphylaxis? (as on the ASCIA Action Plan)

<table>
<thead>
<tr>
<th>AZ</th>
<th>1. Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. No</td>
</tr>
</tbody>
</table>

#### 6.2 Did the pharmacist tell the patient to call an ambulance after using EpiPen/Anapen?

<table>
<thead>
<tr>
<th>BA</th>
<th>1. Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. No</td>
</tr>
</tbody>
</table>

#### 6.3 Did the pharmacist explain storage conditions? (do not refrigerate; 15-25C)

<table>
<thead>
<tr>
<th>BB</th>
<th>1. Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. No</td>
</tr>
</tbody>
</table>
### 7. Antihistamine Assessment and Recommendation

<table>
<thead>
<tr>
<th>Code</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>6.4 Did the pharmacist explain any of the side effects of adrenaline? (e.g. tremor, palpitations, headache)</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td>BD</td>
<td>6.5 Did the pharmacist identify the expiry date of the device?</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td>BE</td>
<td>7.1 Did the pharmacist offer a choice of sedating or non sedating antihistamine?</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td>BF</td>
<td>7.2 Did the pharmacist counsel on the use of antihistamines in anaphylaxis?</td>
</tr>
<tr>
<td></td>
<td>1 Yes, counselled in the context of anaphylaxis</td>
</tr>
<tr>
<td></td>
<td>2 No, counselled in the context of other allergy</td>
</tr>
<tr>
<td></td>
<td>3 Directed to pack instructions without verbal counselling</td>
</tr>
<tr>
<td></td>
<td>4 No counselling with the sale of an antihistamine</td>
</tr>
<tr>
<td></td>
<td>5 No counselling as antihistamine sale refused</td>
</tr>
<tr>
<td>BG</td>
<td>7.3 Did the pharmacist state the dose of antihistamine?</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td></td>
<td>3 No antihistamine sold</td>
</tr>
<tr>
<td>BH</td>
<td>7.4 Did the pharmacist state when to use the antihistamine: (in the context of mild to moderate allergic reaction that may precede anaphylaxis)</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td></td>
<td>3 No antihistamine sold</td>
</tr>
<tr>
<td>BI</td>
<td>7.5 Did the pharmacist state: If no improvement after antihistamine, administer adrenaline autoinjector</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td></td>
<td>3 No antihistamine sold</td>
</tr>
<tr>
<td>BJ</td>
<td>7.6 Did the pharmacist sell an antihistamine to the patient?</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td></td>
<td>2 No</td>
</tr>
<tr>
<td></td>
<td>7.7 Select the reasons stated by the pharmacist for NOT recommending the patient use an antihistamine</td>
</tr>
<tr>
<td>Code</td>
<td>1=Yes, 2=No</td>
</tr>
</tbody>
</table>

**Code:**

- BK - Anaphylaxis occurs too fast for an antihistamine to be of benefit
- BL - Antihistamines are ineffective in treating anaphylaxis
- BM - Other: State but do not enter text to database
- BN - No reason given for non recommendation of antihistamine
- BO - Antihistamine was recommended and sold
## 7.8 Antihistamine sold: select the product chosen

<table>
<thead>
<tr>
<th>BP</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dexchlorpheniramine</td>
</tr>
<tr>
<td>2</td>
<td>Promethazine</td>
</tr>
<tr>
<td>3</td>
<td>Cetirizine</td>
</tr>
<tr>
<td>4</td>
<td>Desloratidine</td>
</tr>
<tr>
<td>5</td>
<td>Fexofenadine</td>
</tr>
<tr>
<td>6</td>
<td>Levocetirizine</td>
</tr>
<tr>
<td>7</td>
<td>Loratidine</td>
</tr>
<tr>
<td>8</td>
<td>Other (state):</td>
</tr>
<tr>
<td>9</td>
<td>No antihistamine sold</td>
</tr>
</tbody>
</table>

END OF DATA COLLECTION FORM
Appendix 6 – ASCIA Action Plans for Anaphylaxis.
Appendices

ACTION PLAN FOR Anaphylaxis

for use with Anapen® or Anapen® Jr adrenaline autoinjectors

MILD TO MODERATE ALLERGIC REACTION

- swelling of lips, face, eyes
- hives or welts
- tingling mouth
- abdominal pain, vomiting (these are signs of a severe allergic reaction to insects)

ACTION

- For insect allergy, flick out sting if visible. Do not remove ticks
- Stay with person and call for help
- Give medications (if prescribed)
  Dose: ..........................................................
- Locate Anapen® or Anapen® Jr
- Contact family/emergency contact

Watch for any one of the following signs of Anaphylaxis

ANAPHYLAXIS (SEVERE ALLERGIC REACTION)

- difficult/noisy breathing
- swelling of tongue
- swelling/tightness in throat
- difficulty talking and/or hoarse voice
- wheeze or persistent cough
- persistent dizziness or collapse
- pale and floppy (young children)

ACTION

1. Lay person flat, do not stand or walk. If breathing is difficult allow to sit
2. Give Anapen® or Anapen® Jr
3. Phone ambulance - 000 (AU), 111 (NZ), 112 (mobile)
4. Contact family/emergency contact
5. Further adrenaline doses may be given if no response after
   5 minutes (if another adrenaline autoinjector is available)
   If in doubt, give Anapen® or Anapen® Jr

Anapen® Jr is generally prescribed for children aged 1–5 years.
*Medical observation in hospital for at least 6 hours is recommended after anaphylaxis.

Additional information
Appendix 7 – Research Proposal (Future research suggestion number 6, section 7.5).

**Epidemiology of Anaphylaxis in Western Australia (EPAWA): identifying the burden and management of anaphylaxis in the WA population.**

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Unit of Clinical Epidemiology  
School of Population Health M431  
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**Clinical Assoc Prof Richard Loh**  
School of Paediatrics and Child Health  
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Crawley WA 6009

Head of Immunology  
Princess Margaret Hospital for Children  
Roberts Road, Subiaco WA 6008

**Prof Ian Jacobs**  
Professor of Resuscitation and Pre-Hospital Care  
Director - Prehospital Resuscitation & Emergency Care Research Unit  
Curtin University  
Kent Street  
Bentley WA 6102

Clinical Services Director  
St John Ambulance Australia  
209 Great Eastern Highway  
Belmont WA 6984
PROPOSED STUDY

Title:
Epidemiology of Anaphylaxis in Western Australia (EPAWA): identifying the burden and management of anaphylaxis in the WA population.

Background:
Anaphylaxis is defined as a severe allergic reaction that is rapid in onset and might cause death.\(^1\) Previously the lifetime prevalence of anaphylaxis was estimated at 0.05%-2%,\(^1,2\) however in the past decade there has been a five-fold increase in potentially anaphylactic food allergies in young children\(^3\), and new population estimates are required. There is evidence anaphylaxis is increasing in prevalence and disproportionately affects children and adolescents.\(^1,4\)

It is frequently reported in the literature that the true incidence and prevalence of anaphylaxis is difficult to determine.\(^1,5-9\) Various factors contribute to this, including an historical lack of consensus on the definition of anaphylaxis, insufficient and inadequate International Classification of Diseases (ICD) codes, and poor coding of anaphylaxis (eg as an alternative diagnosis such as acute asthma or stridor). Anaphylaxis in the community poses an additional challenge, as not all anaphylaxis survivors seek medical assistance\(^10,11\) and so may not be included in population estimates.

A number of methods have been used to determine anaphylaxis epidemiology. An Australian study assessed hospital admission data from the National Hospital Morbidity Database to examine anaphylaxis epidemiology trends from 1993-4 to 2004-5.\(^6\) This study provided useful insight, however is limited in terms of true population estimates as events (rather than individuals) were counted. Another retrospective audit examined all admissions to a paediatric hospital in Brisbane, Australia, over a three-year period (1998-2001).\(^7\) Both studies used ICD codes to identify patients. An alternative method utilised dispensing claims data for all outpatient adrenaline formulations over a five-year period to 2000, in Manitoba, Canada.\(^12\) Review studies have attempted to integrate existing data, although the results are not encouraging: a review of all major epidemiology studies of anaphylaxis, from 1968-2004, found “data on anaphylaxis incidence and prevalence to be sparse and often imprecise”.\(^2\) The same review identified children and adolescents as the group with the highest incidence of anaphylaxis. Recently, an Australian team quantified current rates of severe allergy in infants, through a Victorian population based sample of over 2800 infants; over 10% had food-challenge proven severe food allergy with the potential for anaphylaxis.\(^13\)
In March 2011, The World Allergy Organization (WAO) Anaphylaxis Guidelines were published. These guidelines include detail on anaphylaxis triggers, clinical diagnosis, management (in both healthcare and community settings), risk factors for severe or fatal anaphylaxis, and significant detail on drug therapy. The mainstay of therapy in anaphylaxis is adrenaline. Other pharmacological agents may be employed second line, including antihistamines, beta-2 adrenergic agonists, and glucocorticosteroids.

Adrenaline auto-injector devices (AAIDs) are universally recommended as first-aid for anaphylaxis occurring in the community. In Australia, patients are able to access AAIDs on subsidised prescription via the Pharmaceutical Benefits Scheme (PBS), or through hospital pharmacy services on discharge from hospital. In addition, patients may choose to purchase an AAID from a pharmacy, under the direct advice of a pharmacist and without a doctor’s prescription. Worldwide, there are five different AAIDs marketed for the management of anaphylaxis. Currently two of these devices are approved for marketing in Australia, EpiPen and Anapen. Until recently, EpiPen was the only device available in Australia; Anapen was listed as a benefit on the PBS in September 2010. Further, a new-look EpiPen was launched in Australia in July 2011, meaning that for a crossover period there were three AAIDs available to consumers. This is significant: the devices look different and have different administration techniques.

Anaphylaxis in the community may occur rapidly, where no health professional is present, or where accessibility to emergency services is limited. Therefore, consumers need sufficient training and provision of supporting written plans to be prepared for such events. In one large study of anaphylaxis survivors (n=1885), almost half the participants had not received AAID training. In a cross-sectional study assessing the need for community pharmacist-provided training (n=1887), oral counselling was not provided for over 86% of pharmacist dispensed AAID prescriptions. A short survey conducted to assess the training provided by physicians to parents of children with anaphylaxis for AAID (n=98) showed that in up to 92% of cases, device demonstration was not performed. There is concern that adrenaline autoinjectors may be underused, even when prescribed. Patients, their family and friends, schools and childcare services and primary care health professionals may be inconsistent in their use of adrenaline auto-injectors. There may be an associated knowledge gap and multiple other factors impacting on the use of AAIDs by consumers in an emergency.

With the increased burden of persons at risk of anaphylaxis, the increasing complexity of adrenaline autoinjector devices, and an historical lack of adequate consumer education, the risk of increased anaphylaxis fatalities rises. The direct cost to the healthcare system similarly rises
with emergency services, hospital, outpatient, physician and pharmacy needs. Accurate epidemiology data will help identify areas where improvements at these levels can be made, and in turn drive funding for programs that ultimately reduce the morbidity and mortality of anaphylaxis.

Therefore, there is a need for accurate data on persons at risk of anaphylaxis, number of cases of anaphylaxis each year and whether treatment with adrenaline autoinjectors is used in the community. There is no published research describing events of anaphylaxis, case fatality, near misses and their surrounding circumstances in Western Australia. In addition, there is a lack of evidence of ‘in-practice’ management of anaphylaxis, especially in the community. There is no published research describing the epidemiology of anaphylaxis in Western Australia. Data linkage is a powerful research technique that provides quality epidemiology data, however there are no published data linkage studies of anaphylaxis epidemiology worldwide. The EPAWA study is designed to address the questions of anaphylaxis epidemiology, and management of anaphylaxis in the Western Australian population.
RESEARCH DIRECTION

Aims:
This research aims to:
1. Determine the epidemiological parameters of anaphylaxis, and
2. Evaluate current management of anaphylaxis in the Western Australian population.

These aims are addressed through two related objectives.

Objectives:

Objective 1. To determine epidemiological parameters of anaphylaxis in the Western Australian population, using data linkage.

Key points of this objective are to:
- Identify the Western Australian anaphylaxis cohort (1980-2014)
- Determine epidemiological parameters for anaphylaxis (1990-2014);
- Identify trends in anaphylaxis risk based on key variables;
- Assess trends in incidence and prevalence of hospital admissions, emergency department presentations and St John Ambulance attendance for anaphylaxis;

This objective will be achieved using linked data on hospital admissions, emergency department presentations and mortality (all core datasets of the Western Australian Data Linkage System (WADLS)) and St John Ambulance attendance (a dataset requiring linkage to those above). Cross-Jurisdictional legislation exists between the Commonwealth and Western Australian governments to link Pharmaceutical Benefits Scheme (PBS) data with the WADLS, however no new applications for data are being accepted and linkage of PBS data is not possible. Instead, PBS statistical data and adrenaline autoinjector device sales data (from pharmaceutical manufacturers) will be used to assess trends in adrenaline autoinjector supply and estimate wastage from expired devices.
Appendices

**Objective 2.** To review pharmacological management of acute anaphylaxis, through assessment of a subset of cases identified in the data linkage process.

A subset of identifiable cases will be generated for specific study of pharmacological management of anaphylaxis. Ambulance and hospital records for anaphylaxis patients 2007-2014 will be assessed manually. Key variables will be investigated to determine:

- Current pharmacological management of anaphylaxis;
- Trends in adrenaline autoinjector use (or non-use) in the community by patients with anaphylaxis;
- Differences in adrenaline autoinjector use based on geographical location.

**Methodology:**

**Study Design**

The EPAWA study is a data linkage project that will identify an historical anaphylaxis cohort in the Western Australian population from 1980-2014 (the *WA Anaphylaxis Cohort*), with incidence and prevalence measured by point estimates over a 25-year period (1990-2014).

**Phases of Research**

The EPAWA study will involve four principal research phases:

1. Data Linkage:

   The following core datasets are routinely linked by the Western Australian Data Linkage System (WADLS):
   - Hospital Morbidity Data Collection (HMDC; includes admissions to any hospital in WA, public or private): since 1970, however the quality of the links is high only from 1979 onwards;
   - Emergency Department Data Collection (EDDC; includes attendance at any public hospital emergency department in WA, including co-located private hospitals and excluding solely private hospitals): since 2002;
   - Mortality Register (any death registered in Western Australia): since 1969.

St John Ambulance (SJA) data have not historically been linked, although records have been linked previously for specific projects, and an infrastructure arrangement is planned. It is essential to link SJA records to identify cases of anaphylaxis in the community that may have been incorrectly coded or not coded in hospital databases. This is because most cases of
anaphylaxis in the community are not admitted to hospital (and thus would not have an entry in the HMDC), but are either self-treated in the community with their own AAID, or treated by SJA paramedics prior to attending an emergency department. Coding of anaphylaxis in Western Australian hospitals is complex: EDDC records use a different set of codes from those used for HMDC, and EDDC codes are limited compared to the more comprehensive set available to HMDC. Therefore it is possible that a patient with anaphylaxis who presents to an emergency department but is not admitted may not have an anaphylaxis code recorded in the EDDC, and may only be identified as an anaphylaxis case in the SJA database. Approval to link SJA records will be sought from the SJA Data Custodian (see section I: Approvals). Provision of anaphylaxis cases from the SJA dataset to the WA Data Linkage Branch (WADLB) will be made subject to Approval. The time period covered by the cases will depend on previous SJA linkage with the WADLS and approvals granted by SJA. The SJA records will then be linked with corresponding records from the three datasets outlined above, namely HMDC, EDDC and Mortality.

2. Data Extraction:

In accordance with WADLS requirements, approval to extract data will be sought from the individual Data Custodians for the HMDC, EDDC and Mortality datasets (see section I: Approvals).

Anaphylaxis events for the period 1980-2014 will be identified based on relevant codes or text. These include:

- The World Health Organization’s International Statistical Classification of Diseases (ICD) diagnosis codes;
- The EDDC Symptom Codes;
- Free text field searching where no coding exists or is unreliably recorded;
- External Cause codes.

This period encompasses ICD versions 9, 9 CM, 9CM Australian version 2, and 10 AM versions 1 through 7. Events will include those arising in the community as well as in hospital (for example, patients admitted for a different indication, who develop anaphylaxis during the course of their admission). Preliminary ICD and symptom codes have been identified for anaphylaxis and external causes, including wide population codes. Final codes used will be determined in consultation with clinical coding experts from Perth metropolitan hospitals.
All cases for the period 1980-2014 with anaphylaxis will be extracted from the HMDC, EDDC, Mortality and SJA linked datasets and will form the WA Anaphylaxis Cohort. Data extracted in this phase will be analysed to determine anaphylaxis incidence, prevalence, rates of admission and trends.

A random sample of 1000 cases from a subset of the WA Anaphylaxis Cohort who were admitted to Perth metropolitan hospitals for the period 2007-2014 will be identified and used for case review.

3. Case Review:

The subset of cases from WA Anaphylaxis Cohort will be identifiable by their Unit Medical Record Number (UMRN), hospital code and ambulance code to allow extraction of data from medical notes (hospitals and St John Ambulance services). The clinical data to be obtained from medical notes are not available from the linked core datasets of the WA Data Linkage System. Data to be obtained includes the use of life-saving adrenaline, which can be administered by non-medical persons in the community. Adrenaline autoinjector devices are prescribed to persons at risk of anaphylaxis, for individual management of anaphylaxis, in the absence of access to immediate emergency medical care. Other medicines may be administered inappropriately instead of adrenaline. Details of pharmacological management are not recorded in the existing datasets and case note review is the only way to identify this information. Other factors that may impact on the use or non-use of adrenaline autoinjectors may be ascertainable through case note review. Identifying this information is key to planning initiatives to improve management of anaphylaxis in community settings. It is also essential to review ambulance and hospital records at the individual level, to identify near-miss anaphylaxis mortality and the surrounding circumstances in the community setting. Better description of anaphylaxis morbidity is possible through case review. This information is essential to describe anaphylaxis epidemiology and management of anaphylaxis for the WA population.

The lists of UMRN will be provided to the medical records departments at metropolitan hospitals, who will pull patient notes for review. A research assistant will enter the necessary information into a Microsoft Access database containing encrypted root number. Identifying information (including UMRN) will not be collected. A similar procedure will be used for SJA records. A file of SJA record number and encrypted root number will be provided and information from the ambulance records will be collected in this Access database. Again, this will only contain the encrypted root number and no identifying information.
When the case review is completed, the files of identifying information will be permanently destroyed. The researchers will not attempt to re-identify any individual.

Variables to be reviewed in hospital and ambulance records are identified in the following table:

<table>
<thead>
<tr>
<th>Hospital Variables</th>
<th>St John Ambulance Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic Data</strong></td>
<td>Age, gender, dates of admission and discharge, principal diagnosis (ICD code), external causes of episode of care, place of occurrence of episode of care, health region and postcode of residence</td>
</tr>
<tr>
<td><strong>Clinical Data</strong></td>
<td>Age, gender, principal diagnosis (anaphylaxis), date and location of episode (eg school, childcare, shopping centre, sports oval, restaurant, home)</td>
</tr>
<tr>
<td>Adrenaline autoinjector use or non-use; supplemental adrenaline use (either autoinjector or other forms); antihistamine, glucocorticosteroid or beta-2 agonist use; other supplemental management to discriminate severe anaphylaxis from anaphylaxis (eg ICU admission, other supportive therapy); allergen identified; referral to allergy specialist; provision of an anaphylaxis management plan and adrenaline autoinjector to patient on discharge.</td>
<td>Adrenaline autoinjector use by patient or carer prior to ambulance attendance; adrenaline autoinjector (or other adrenaline) use by paramedics during ambulance attendance; time of initial adrenaline use (by ambulance paramedics or patient prior to ambulance attendance); time of onset of anaphylaxis; supplemental adrenaline used by ambulance services; time of supplemental or repeat adrenaline use; location of first adrenaline autoinjector use (eg in the home, school, shopping centre, restaurant); location of subsequent (supplemental) adrenaline autoinjector use (eg ambulance, hospital); antihistamine use by patient prior to ambulance service attendance; glucocorticoid or beta-2 agonist use; identification of suspected allergen; cause of anaphylaxis.</td>
</tr>
</tbody>
</table>

4. Adrenaline autoinjector supply and wastage estimates:

Additional unlinked data will be obtained from historical estimates of adrenaline autoinjector supply through sales history data (from device manufacturers; 1980-most recent), and Pharmaceutical Benefits Scheme statistical data (1992 to most recent). These estimates will assist in identifying trends in new diagnoses of anaphylaxis, and may estimate wastage associated with unused or expired devices.

**Analysis**

Analysis will be performed using Statistical Analysis System (SAS) and Microsoft Excel software packages and will include but is not limited to:

- Age-standardised rates of admission for anaphylaxis and mortality rates in the Western Australian population;
Appendices

- Cox survival analysis will be used to estimate the risk of readmission (emergency department or hospital inpatient) for anaphylaxis in people previously admitted for anaphylaxis;
- Rates of provision of a new AAID, written action plan and specialist referral after emergency department presentation for anaphylaxis;
- Causative allergen rates;
- Impact of location of episode of anaphylaxis on use of AAIDs;
- Differences in outcome based on pharmacological management will be assessed in the subset of patients with data from case notes.
BIBLIOGRAPHY:


