


REVIEW

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Quality indicators for the acute and long-term management of anaphylaxis: a systematic review

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Abstract

Background: The quality of acute and long-term anaphylaxis management is variable and this contributes to the poor outcomes experienced by many patients. Clinical practice guidelines have the potential to improve outcomes, but implementing guideline recommendations in routine practice is challenging. Quality indicators have the potential to support guideline implementation efforts.

Objective: To identify quality indicators to support the acute and long-term management of anaphylaxis.

Methods: We conducted a systematic review of the literature that involved searching Medline, EMBASE and CINAHL databases for peer-reviewed published literature for the period 1 January 2005–31 December 2015. Additionally we searched Google for grey and unpublished literature. The identified indicators were descriptively summarized against the most recent international anaphylaxis guidelines (i.e. those produced by the European Academy of Allergy and Clinical Immunology) and critically evaluated using the Agency for Healthcare Research and Quality's criteria for indicator development.

Results: Our searches revealed 830 publications, from which we identified five sources for 54 indicators addressing both acute ($n = 27$) and long-term ($n = 27$) management of anaphylaxis. The majority of indicators were developed through expert consensus with relatively few of these having been formally piloted or tested to demonstrate that they could discriminate between variations in practice and/or that they were sensitive to change.

Conclusions: There is a need for a comprehensive set of quality indicators for anaphylaxis management. We have however identified some indicators for the acute and long-term management of anaphylaxis that could with relatively little additional work support efforts to translate guideline recommendations into clinical care.

Keywords: Allergy, Anaphylaxis, Guidelines, Implementation research, Indicators, Outcomes, Quality of care, Standards

Background

Anaphylaxis is a “severe, life-threatening generalized or systemic hypersensitivity reaction” [1, 2] that is responsible for considerable morbidity and, in some cases, mortality. The quality of emergency and ongoing care for patients experiencing and/or with a history

of anaphylaxis is variable and this contributes to the poor outcomes (e.g. high risk of recurrent episodes of anaphylaxis) seen [3]. In an attempt to standardize care, and thereby improve outcomes, a number of governments and professional bodies have developed clinical practice guidelines [4–7]. These aim to provide front-line clinicians with simple, concise, evidence-based recommendations for clinical care. Whilst undoubtedly a welcome development, there is a growing body of evidence demonstrating that guidelines often prove challenging to implement in routine clinical care [8]. To support this implementation process, attention is increasingly

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focusing on the need to develop tools that can help clinicians implement key recommendations and monitor progress with implementation efforts [9].

Quality standards and indicators are potentially important tools designed to help clinicians and healthcare organisations assess the quality of care being provided against agreed evidence-based recommendations [9]. These are now being used across a number of disease and clinical areas, but we are unaware of these currently being routinely used at scale in relation to anaphylaxis.

We are developing evidence-based tools to support translation of key anaphylaxis recommendations into clinical practice and in order to inform this process we undertook a systematic review to identify existing quality indicators for anaphylaxis and identify gaps where there is a need for further development.

Methods

Overview of methods, registration and reporting

We conducted a systematic review of the literature that involved searching for published and unpublished literature. It is registered in the PROSPERO database with registration number CRD42016035381. We reported findings using the principles advocated in the PRISMA guidelines [10] (Additional file 1).

Search strategy

We developed a highly sensitive search strategy to identify papers on standards and/or quality indicators for anaphylaxis. This involved searching Medline, EMBASE and CINAHL databases for peer-reviewed published literature, and the Google database for searching grey literature published during the period 1 January 2005–31 December 2015. No language restrictions were employed. Our search terms are detailed in the [Appendix](#).

Inclusion criteria

We were interested in publications reporting on indicators for measuring the quality of acute and long-term care of anaphylaxis in patients of any age. We did not specify any criteria on how these were developed and there was therefore no study filter employed in selecting papers.

Selection of indicators

Two reviewers independently selected manuscripts against the pre-specified inclusion criteria. Disagreements were resolved through discussion with arbitration by a third reviewer, where necessary.

Data extraction

Two reviewers independently extracted indicator data onto a customized data extraction sheet. Disagreements

were resolved through discussion; a third reviewer arbitrated in instances where agreement could not be reached. Where available, we also extracted data on how these indicators were developed, whether they had been tested and if they had been used in experimental contexts to demonstrate that they could capture improvements in the quality of care.

Quality assessment of indicators

The quality of these indicators was then assessed against the criteria detailed using the four stage quality indicator process recommended by the Agency for Healthcare Research and Quality (AHRQ), namely:

1. Development: Identifying candidate indicators through a literature review and/or discussion with experts;
2. Implementation: Testing of candidate indicators, introducing them into software etc.;
3. Maintenance: Indicators need to be regularly checked and, if necessary, updated to keep abreast of latest developments; and
4. Retirement processes: Indicators need to be assessed at periodic intervals for relevance and in order to assess if they need to be discontinued [11].

We contacted the authors of these development tools for further clarification, if necessary.

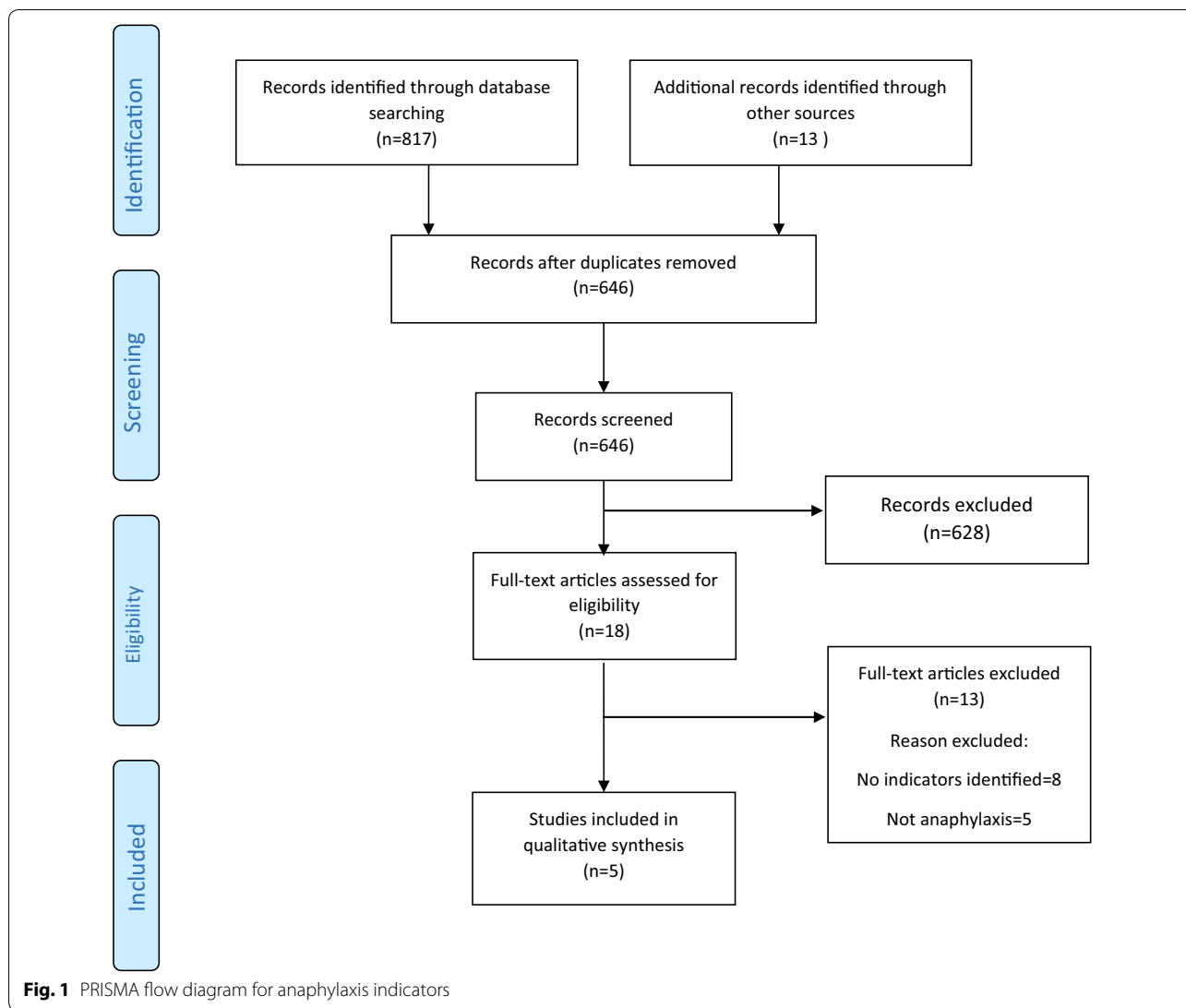
Data synthesis

We then mapped available indicators against the various recommendations in the most recent international anaphylaxis guidelines, namely those produced by the European Academy of Allergy and Clinical Immunology (EAACI) [12], identifying areas of overlap and gaps, and making an overall assessment of whether any particular indicator was considered appropriate for use in routine clinical practice. Available indicators were traffic-light color coded with green indicating that the indicators were suitable/nearly suitable for routine use as they had undergone the AHRQ process, amber indicating the need for some additional work, and red indicating the need for a substantial amount of additional underpinning work as most of the stages suggested by AHRQ had not been followed.

Results

Characteristics of included studies

Our searches identified 830 studies, of which five satisfied our inclusion criteria (see Fig. 1) [12–16]. The five sources of indicators are detailed in Table 1. In total, 54 individual indicators were identified: 27 for the acute management of anaphylaxis and the remaining 27 for



longer-term management. Indicators for the acute and longer-term management of anaphylaxis were identified by four of the five sources [12, 14–16]. Two sources of indicators only focused on children and young people [16, 17], and one focused solely on children attending Emergency Departments (ED) for the acute management of anaphylaxis [17].

Geographically, three sets of indicators were developed in the United Kingdom (UK) [14–16], the fourth was developed in Canada [17] and the fifth was pan-European in origin [12].

Assessment of indicators against AHRQ criteria

Table 2 summarizes our assessment of the quality of the indicators against each of the four criteria stipulated by AHRQ.

1. Measure development

The EAACI indicators [12] were derived from clinical guidelines in relation to key recommendations. The Levy indicators [14] were developed through expert consensus. The National Institute of Health and Clinical Excellence (NICE) indicators were derived from relevant guideline recommendations [15]. The Royal College of Paediatrics and Child Health (RCPCH) indicators were derived from a care pathway for children with suspected anaphylaxis [16]. The Stang indicators [17] were the only ones that had been developed through the stages suggested by AHRQ, namely formal processes to identify and assess indicators; furthermore, these were developed using National Quality Framework (NQF) measure evaluation criteria [19].

Table 1 Source of indicators for the acute and long-term management of anaphylaxis

Author, year, country	Title	Indicators for the acute management of anaphylaxis	Indicators for the long-term management of anaphylaxis	No of indicators
European Academy of Allergy and Clinical Immunology (EAACI), 2014, Europe	Anaphylaxis: guidelines from the European Academy of Allergy and Clinical Immunology	Yes	Yes	24
Levy M, 2008, UK	Audit of self-administered injectable adrenaline prescription in primary care	Yes	Yes	6
National Institute for Health and Clinical Excellence (NICE), 2011, UK	Anaphylaxis clinical audit tool implementing NICE guidelines	Yes	Yes	8
Royal College of Paediatrics and Child Health (RCPCH), 2011, UK	RCPCH Allergy Care Pathways Project Audit criteria	Yes	Yes	9
Stang AS, et al., 2013, Canada	Quality indicators for high acuity pediatric conditions	Yes	No	7

2. Implementation

The EAACI indicators [12] did not have any formal implementation assessment. The Levy indicators [14] are freely available for use from http://www.guideline-audit.com/adrenaline/audit_specification.php and had been successfully implemented in a number of UK general practices with the opportunity for benchmarking quality of care. NICE [15] had a generic implementation team and created a range of implementation tools, but it was unclear if the ability to implement these indicators in practice had been formally assessed. The RCPCH [16] give no mention of an implementation strategy. The Stang indicators were operationalized and tested in an ED setting [17].

3. Maintenance

None of the indicators had plans for formal maintenance checks.

4. Retirement

There were no plans for retirement of indicators, although EAACI [12], NICE [15] and the RCPCH [16] stated that they had established processes for the periodic review of their clinical guidelines/pathways.

Mapping of indicators against guideline recommendations

The EAACI Guidelines [12] made 16 recommendations on the acute management of anaphylaxis and indicators were developed by EAACI for all of these recommendations (Table 3). Six of these recommendations also had indicators identified from the other sources.

For the longer-term management of anaphylaxis, EAACI made eight recommendations and indicators were developed by EAACI for all of these (Table 4). Additional indicators from other sources were identified for five of these recommendations.

Tables 3 and 4 have been colour coded according to their compliance with the AHRQ criteria to show which

indicators are fit-for-purpose. Green identifies indicators that have been developed according to AHRQ principles and are ready to implement, red shows the indicators that need more developmental work before they can be implemented and amber falls between the two. These tables show that the Stang et al. [17] (coded green) and Levy [14] (coded amber) indicators could with relatively modest effort be rendered fit-for-purpose; gaps still however remained in relation to both acute and long-term management (coded red) where considerable development work is still required.

Discussion

Statement of principal findings

This study has demonstrated that there are now candidate quality indicators covering many aspects of the acute and long-term management of anaphylaxis. Only a few of these have however undergone the four stages of development recommended by AHRQ, namely implementation and maintenance and none of them have considered decisions on the maintenance or retirement of quality indicators [11]. Further work is therefore needed before any of these can be recommended for routine use in clinical practice [17]. That said, the indicators developed by Stang et al. [16] for acute management of anaphylaxis and those developed by Levy [14] for long-term management could be rendered fit-for-purpose with relatively modest additional effort. EAACI should therefore consider undertaking this work and adopting these indicators. Other areas in relation to both acute and long-term management require much more development work and evaluation.

Strengths and limitations

The key strengths of this work are that we used systematic review methods to identify relevant literature,

Table 3 Indicators for the acute management of anaphylaxis mapped to EAACI recommendations with assessment of indicator quality

Recommendation	Indicator	Source
Adrenaline is potentially life-saving and must therefore promptly be administered as the first-line treatment for the emergency management of anaphylaxis	% of children treated with an intramuscular adrenaline injection for an acute anaphylaxis reaction	Stang et al
	% of patients with anaphylaxis who received epinephrine in ED	Stang et al
	100% of patients prescribed Adrenaline Auto-injectors should be for the correct dose	Levy
	% of patients at risk of anaphylaxis who have an unexpired adrenaline auto-injector	EAACI
	% of patients experiencing anaphylaxis who are promptly treated with adrenaline	EAACI
	The time of onset of the reaction should be recorded	NICE
Earlier administration of adrenaline should be considered on an individual basis when an allergic reaction is likely to develop into anaphylaxis	% of patients experiencing anaphylaxis who are promptly treated with adrenaline	EAACI
Adrenaline should be administered by intramuscular injection into the mid outer thigh	% of patients treated with epinephrine in ED treated by the appropriate route	Stang et al
	% of children treated with an intramuscular adrenaline injection for an acute anaphylaxis reaction	Stang et al
	% of patients who give the auto-injector into the mid-outer thigh	NICE
	Percentage of children treated with an intramuscular adrenaline injection for an acute anaphylaxis reaction	RCPCH
In patients requiring repeat doses of adrenaline, these should be administered at least 5 minutes apart	% of patients treated with >1 dose adrenaline, timing and who administered (parents, paramedics, self)	EAACI

Table 3 continued

Recommendation	Indicator	Source
With inadequate response to 2 or more doses of intramuscular adrenaline, adrenaline may be administered as an infusion by appropriately experienced intensive care, emergency department and critical care physicians, with appropriate cardiac monitoring	% of patients requiring intensive care support with anaphylaxis Outcome if require ≥ 2 doses intramuscular adrenaline	EAACI
Trigger of the anaphylaxis episode should be removed	Time taken for removal of trigger among patients with anaphylaxis from medication or blood products The circumstances immediately before the onset of symptoms should be recorded to help to identify the possible trigger	EAACI NICE
Help should be called promptly and simultaneously with patient’s assessment	Whether and when help is called	EAACI
Patients experiencing anaphylaxis should be positioned supine with elevated lower extremities if they have circulatory instability, sitting up if they have respiratory distress and in recovery position if unconscious	In patients with previous anaphylaxis, determine proportion of patients placed in the correct position whilst receiving treatment	EAACI
High flow oxygen should be administered by face mask to all patients with anaphylaxis	% of patients with anaphylaxis that were given high flow oxygen in the community (ambulance) and in hospital	EAACI
Intravenous fluids (crystalloids) should be administered (boluses of 20 ml/kg) in patients experiencing cardiovascular instability	% of patients with anaphylaxis who received IV fluids (bolus and maintenance) % of patients with blood pressure measurement as part of initial observations	EAACI EAACI
Inhaled short-acting beta-2 agonists should additionally be given to relieve symptoms of bronchoconstriction	% of patients with lower respiratory symptoms in the context of anaphylaxis given adrenaline % of patients with lower respiratory symptoms in the context of anaphylaxis inhaled beta-2-agonists but not adrenaline	EAACI EAACI

Table 3 continued

Recommendation	Indicator	Source
Oral H1- (& H2)-antihistamines may relieve cutaneous symptoms of anaphylaxis	% of patients with anaphylaxis who self-administered antihistamines prior to adrenaline	EAACI
Systemic glucocorticosteroids may be used as they may reduce the risk of late phase respiratory symptoms. High dose nebulized glucocorticoids may be beneficial for upper airway obstruction	% of patients who received adrenaline treatment with and without glucocorticosteroids	EAACI
Patients who presented with respiratory compromise should be closely monitored for at least 6-8 hours and patients who presented with circulatory instability require close monitoring for 12-24 hours	% of patients discharged within 6 hours compared to > 24 hours and outcome of reaction e.g. development of biphasic response, or need for repeat dose adrenaline	EAACI
	% of children with an acute episode of anaphylaxis transferred to hospital	RCPHCP
	% of children with an acute episode of anaphylaxis who are transferred to hospital are observed for a minimum of 4 hours	RCPHCP
	All children younger than 16 years given emergency treatment for suspected anaphylaxis should be admitted to hospital under the care of a paediatric medical team	NICE
Before discharge, the risk of future reactions should be assessed and an adrenaline auto-injector should be prescribed to those at risk of recurrence	% of patients prescribed adrenaline auto-injector upon discharge following anaphylaxis	EAACI
	After emergency treatment for suspected anaphylaxis, people (or, as appropriate, their parent and/or carer) should be offered an appropriate adrenaline injector as an interim measure before the specialist allergy service appointment	NICE

formally considered the appropriateness of the methods to develop and deploy these indicators using the four stage process recommended by the AHRQ [11] and then systematically mapped these against the recent EAACI anaphylaxis guidelines [5].

The limitations of this work also need to be considered. This includes the possibility that we failed to identify relevant literature and indicators, although we tried to minimize this risk by not having any restriction of languages on our searches, searching grey literature and by

Table 3 continued

Recommendation	Indicator	Source
Patients should be provided with a discharge advice sheet, including allergen avoidance measures (where possible) and instructions for the use of the adrenaline auto-injector. Specialist and food allergy specialist dietitian (in food anaphylaxis) follow-up should be organized. Contact information for patient support groups should also be provided	% of patients with discharge advice sheet and training on use of adrenaline auto-injector upon discharge following anaphylaxis	EAAI
	After emergency treatment for suspected anaphylaxis, people should be offered a referral to a specialist allergy service	NICE
	Before discharge a healthcare professional with the appropriate skills and competencies should offer people (or, as appropriate, their parent and/or carer) the following:	NICE
	•information about anaphylaxis, including the signs and symptoms of an anaphylactic reaction	
	•information about the risk of a biphasic reaction	
	•information on what to do if an anaphylactic reaction occurs (use the adrenaline injector and call emergency services)	
	•a demonstration of the correct use of the adrenaline injector and when to use it	
	•advice about how to avoid the suspected trigger (if known)	
	•information about the need for referral to a specialist allergy service and the referral process	
	•information about patient support groups	

contacting a panel of experts. There may also have been experiences of using these indicators that have not yet found their way into the peer-reviewed or grey literature. This issue could be further investigated through, for example, contacting electronic health record and software vendors to see which if any have been computed and with what results.

Interpretation in the light of other published literature

Anaphylaxis, in comparison to other disease areas, is relatively undeveloped in terms of quality indicators [18]. For example, NICE has developed indicators for a number of disorders—particularly long-term conditions—that have been used to incentivize improvements in care through the UK Quality and Outcomes Framework (QOF) [19, 20]. Examples of areas in which these have been used include asthma, atrial fibrillation, blood pressure and cancer care [21]. Similarly, in the US indicators

are in widespread use in hospital practice focusing, for example, on re-hospitalization of patients within 30 days of discharge, which can be used to penalize hospitals [22, 23]. By imposing financial penalties for those with the highest readmission rates and thus penalizing those with poor levels of care, the hope is to improve the quality of care delivered [24].

Implications for policy, practice and research

Indicator development, implementation testing, and maintenance and retirement considerations should be seen as integral to the process of producing guidelines as this will maximize the chances of translating guideline recommendations into routine clinical practice and thereby improve outcomes. Quality indicators can improve this translational process through associated financial incentives and penalties as noted above, but they can also be used in more subtle ways through, for

Table 4 Indicators for the longer-term management of anaphylaxis mapped to EAACI recommendations with assessment of indicator quality

Recommendation	Indicator	Source
An anaphylaxis management plan should be used from the time of diagnosis to prevent future reactions, and aid recognition and treatment of any further reactions	100% of patients with a recorded diagnosis of anaphylaxis have evidence of receiving a written self-management plan.	Levy
	At least 80% of patients with a recorded diagnosis of anaphylaxis have been reviewed in the past year?	Levy
	100% of patients or their parents/representatives with a prescription for self-administered adrenaline should have been taught to use device.	Levy
	At least 80% of patients or their parents/representatives have demonstrated they can use their autoinjector, in the past 12 months	Levy
	At least 80% of patients with a prescription for self-administered adrenaline have a recorded diagnosis of anaphylaxis?	Levy
	% of patients attended the ED because of a further severe allergic reaction and length of ED stay	EAACI

example, benchmarking efforts, supporting audit cycles and quality improvement initiatives. These comparative processes, particularly if they involve financial incentives and fines or reputational damage, need to be undertaken with care and with appropriate case mix adjustment, if appropriate [25].

Key next steps are for a multi-stakeholder group to formally consider these existing candidate indicators, chose between existing indicators, propose alternative indicators where considered necessary, develop additional indicators to fill the recommendation gaps, and then

undertake formal field work to support implementation efforts. In due course, plans also need to be put into place to consider indicator maintenance and retirement related issues. The AHRQ framework can prove useful to guide this process [11].

Conclusions

Indicators were identified for all of the recommendations made in the EAACI Anaphylaxis Guidelines, though none of these satisfied all four criteria specified by AHRQ. There are some indicators, particularly in relation to

Table 4 continued

Recommendation	Indicator	Source
	% of patients hospitalized because of a further severe allergic reaction and length of hospital stay EAACI	
	% of patients died because of a further severe allergic reaction	EAACI
	The acute clinical features should be documented	EAACI
	The circumstances immediately before the onset of symptoms should be recorded to help to identify the possible trigger	NICE
	After emergency treatment for suspected anaphylaxis, people should be offered a referral to a specialist allergy service	NICE
	After emergency treatment for suspected anaphylaxis, people (or, as appropriate, their parent and/or carer) should be offered an appropriate adrenaline injector as an interim measure before the specialist allergy service appointment	NICE
	Percentage of children with an acute episode of anaphylaxis who are investigated with specific allergy tests	RCPCH
	Percentage of children who carry an adrenaline injector who have been weighed for a review of their adrenaline dose	RCPCH
	Percentage of children (and their families) at risk of anaphylaxis educated to use an adrenaline injector at every health care visit for their acute severe allergies	RCPCH

Table 4 continued

Recommendation	Indicator	Source
	<p>Percentage of children with anaphylaxis where the health professionals ensured that schools and early years settings are informed of how to deal with an acute event</p>	<p>RCPCH</p> <p>RCPCH</p>
<p>Subcutaneous venom immunotherapy is recommended in venom allergic patients with a previous episode of anaphylaxis and adults with systemic cutaneous reactions</p>	<p>% of patients who have an increased quality of life compared to those without treatment</p>	<p>EAACI</p>
<p>Training in the recognition and management of anaphylaxis should be offered to all patients and caregivers of children at risk of anaphylaxis ideally from the time of diagnosis</p>	<p>100% of patients or their parents/representatives with a prescription for self-administered adrenaline should have been taught to use device.</p> <p>At least 80% of patients or their parents/representatives have demonstrated they can use their autoinjector, in the past 12 months</p> <p>100% of patients with a recorded diagnosis of anaphylaxis have evidence of receiving a written self-management plan</p> <p>Adrenaline auto-injector training devices should be available in physician offices or hospitals; if no time for training immediate referral to allergist</p>	<p>Levy</p> <p>Levy</p> <p>Levy</p> <p>EAACI</p>

acute management, which would require relatively little effort to render them fit-for-purpose. We also identified some indicators, which may prove suitable in relation to assessing the quality of long-term anaphylaxis care. Other

indicators, however, require much more developmental work. To progress this work, stakeholders now need to consider the findings from this review and then undertake additional formative work to ensure that there are a

Table 4 continued

Recommendation	Indicator	Source
	<p>The acute clinical features should be documented</p> <p>Percentage of children (and their families) at risk of anaphylaxis educated to use an adrenaline injector at every health care visit for their acute severe allergies</p> <p>Percentage of children with anaphylaxis where the health professionals ensured that schools and early years settings are informed of how to deal with an acute event</p>	<p>NICE</p> <p>RCPCH</p> <p>RCPCH</p>
<p>Training in the recognition and management of anaphylaxis, including use of adrenaline auto-injectors, should be offered to all professionals dealing with patients at risk of anaphylaxis</p>	<p>% of EDs with clinical guidelines for the treatment of anaphylaxis in children</p> <p>% of healthcare professionals who are trained in the recognition and management of anaphylaxis</p>	<p>Stang et al</p> <p>EAACI</p>
<p>Training packages should be developed with the target groups</p>	<p>Number and quality of anaphylaxis training packages</p>	<p>EAACI</p>
<p>Training should cover allergen avoidance, symptoms of allergic reactions, when and how to use an adrenaline auto-injector and what other measures are needed within the context of an anaphylaxis management plan</p>	<p>100% of patients or their parents/representatives with a prescription for self-administered adrenaline should have been taught to use device.</p> <p>At least 80% of patients or their parents/representatives have demonstrated they can use their autoinjector, in the past 12 months</p> <p>% of patients or caregivers who receive training</p>	<p>Levy</p> <p>Levy</p> <p>EAACI</p>

Table 4 continued

Recommendation	Indicator	Source
Training may involve more than one session to allow revision, an interactive scenario-based approach, a standardized program with manual and educational material and simulation tools. Content and language should be tailored to be understood and memorized	At least 80% of patients with a recorded diagnosis of anaphylaxis have been reviewed in the past year?	Levy
	100% of patients or their parents/representatives with a prescription for self-administered adrenaline should have been taught to use device.	Levy
	% of patients or caregivers who receive training	EAACI
Educational interventions should ideally incorporate psychological principles and methods to address anxiety so that children and families may function well at home, at school/work, and socially despite their risk of future reactions and should ideally be part of their educational training. This can be done in a group format. Some patients, with severe anxiety of ongoing duration, may need more in-depth one to one psychological intervention	Optimization of adaptive anxiety levels in trained patients and caregivers	EAACI

Green, amber and red show which indicators have been developed according to AHRQ criteria, green being the closest and red the furthest

range of suitable indicators that have been both appropriately developed and demonstrated to work in practice to achieve the desired outcome, namely helping to assess the quality of anaphylaxis care delivered to patients.

Additional file

[Additional file 1.](#) PRISMA checklist.

Authors' contributions

AS conceived this study, which was led by SD. AM, GR, SH, MFR and MW commented on an earlier draft of this manuscript. All authors read and approved the final manuscript.

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Competing interests

AS, GR, AM, GR, SH, MFR and MW are all members of the EAACI Anaphylaxis Guidelines and contributed to the development of the EAACI indicators. AS also contributed to the RCPCH indicators.

Availability of data and material

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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Appendix

Search strategy 1: MEDLINE and EMBASE

1. anaphylaxis/
2. anaphyl*.mp.
3. ((acute or severe or major or serious or life threatening or fatal*) and (allerg* or hypersensiti*)).mp.
4. hypersensitivity immediate/
5. exp food hypersensitivity/
6. respiratory hypersensitivity/
7. exp drug hypersensitivity/
8. ((food or egg? or nut? or peanut? or milk or wheat or drug? or respiratory or asthma* or sting* or venom*) adj3 (allerg* or hypersensiti*).tw.
9. ((allerg* or hypersensiti*) adj5 reaction*).tw.
10. or/1–9
11. quality indicators.mp. or exp Quality Indicators, Health Care/
12. quality standard.mp.
13. "Process Assessment (Health Care)"/or clinical best practice.mp.
14. clinical audit.mp. or exp Clinical Audit/
15. patient experience.mp.
16. (quality and outcomes framework).mp.
17. or/11–16
18. 10 and 17

Search strategy 2: CINAHL

(anaphylaxis or anaphylaxis management) AND (quality indicators or quality standard or clinical audit or patient experience).

Search strategy 3: Google Scholar

Free key word search "anaphylaxis management and quality indicators 2005–2015."

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References

1. Johansson SGO, Bieber T, Dahl R, Friedmann PS, Lanier B, Lockey RF, et al. A revised nomenclature for allergy for global use: report of the Nomenclature Review Committee of World Allergy Organization. *J Allergy Clin Immunol*. 2004;113:832–6.
2. Muraro A, Roberts G, Clark A, Eigenmann PA, Halken S, Lack G, et al. The management of anaphylaxis in childhood: position paper of the European academy of allergology and clinical immunology. *Allergy*. 2007;62(8):857–71.
3. Mullins RJ. Anaphylaxis: risk factors for recurrence. *Clin Exp Allergy*. 2003;33(8):1033–40.
4. Soar J, Pumphrey R, Cant A, Clarke S, Corbett A, Dawson P, et al. Emergency treatment of anaphylactic reactions—guidelines for healthcare providers. *Resuscitation*. 2008;77(2):157–69. doi:10.1016/j.resuscitation.2008.02.001.
5. Muraro A, Roberts G, Worm M, Bilò MB, Brockow K, Fernández Rivas M, et al. Anaphylaxis: guidelines from the European Academy of Allergy and Clinical Immunology. *Allergy*. 2014;69(8):1026–45. doi:10.1111/all.12437.
6. Simons E, Arduoso L, Beatrice Bilò M, El-Gamal Y, Ledford D, Ring J, et al. World Allergy Organization guidelines for the assessment and management of anaphylaxis. *World Allergy Organ J*. 2010;4(2):13–37.
7. Vale S, Smith J, Said M, Mullins R, Loh R. ASCIA guidelines for prevention of anaphylaxis in schools, pre-schools and childcare: 2015 update. *J Paediatr Child Health*. 2015. doi:10.1111/jpc.12962.
8. Shuttleworth A. A practical approach to implementing guidelines. *Nursing Times*, 30 Nov 2007. <http://www.nursingtimes.net/a-practical-approach-to-implementing-guidelines/304506.fullarticle>.
9. NICE quality standards and indicators. <https://www.nice.org.uk/standards-and-indicators>.
10. PRISMA transparent reporting of systematic reviews and meta-analyses. <http://www.prisma-statement.org/PRISMAStatement/Default.aspx>.
11. AHRQ quality indicators: quality indicator measure development, implementation, maintenance, and retirement. http://www.qualityindicators.ahrq.gov/Downloads/Resources/Publications/2011/QI_Measure_Development_Implementation_Maintenance_Retirement_Full_5-3-11.pdf.
12. Muraro A, Roberts G, Worm M, Bilò MB, Brockow K, Fernández Rivas M, et al. Anaphylaxis: guidelines from the European Academy of Allergy and Clinical Immunology. *Allergy*. 2014. doi:10.1111/all.12437.
13. Levy M. Audit of self-administered injectable adrenaline prescription in primary care. http://www.guideline-audit.com/adrenaline/audit_specification.php.
14. National Institute for Health and Clinical Excellence (NICE). Anaphylaxis clinical audit tool implementing NICE guidelines. 2011. <https://www.nice.org.uk/guidance/cg134/resources>.
15. Royal College of Paediatrics and Child Health (RCPCH). RCPCH Allergy Care Pathways Project Audit criteria, Apr 2011. http://www.rcpch.ac.uk/system/files/protected/page/2011_RCPCH_Allergy_Audit_v5_0.pdf.
16. Stang AS, Straus SE, Crotts J, Johnson DW, Guttman A. Quality indicators for high acuity pediatric conditions *Pediatrics*. 2013;132(4). <http://pediatrics.aappublications.org/content/132/4/752.long>.
17. Gill PJ, O'Neill B, Rose P, Mant D, Harnden A. Primary care quality indicators for children: measuring quality in UK general practice. *Br J Gen Pract*. 2014;64(629):e752–7. doi:10.3399/bjgp14X682813.
18. Lee S, Stachler RJ, Ferguson BJ. Defining quality metrics and improving safety and outcome in allergy care. *Int Forum Allergy Rhinol*. 2014;4(4):284–91. doi:10.1002/alf.21284.

19. Roland M. Linking physicians' pay to the quality of care—a major experiment in the United Kingdom. *N Engl J Med*. 2004;351:1448–54. doi:[10.1056/NEJMhpr041294](https://doi.org/10.1056/NEJMhpr041294).
20. Roland M, Campbell S. Successes and failures of pay for performance in the United Kingdom. *N Engl J Med*. 2014;370:1944–9. doi:[10.1056/NEJMhpr1316051](https://doi.org/10.1056/NEJMhpr1316051).
21. The NICE Indicator Menu for the QOF National Institute for Health and Care Excellence. <https://www.nice.org.uk/Standards-and-Indicators/QOFIndicators>.
22. Joynt KE, Jha AK. Characteristics of hospitals receiving penalties under the Hospital Readmissions Reduction Program. *JAMA*. 2013;309(4):342–3. doi:[10.1001/jama.2012.94856](https://doi.org/10.1001/jama.2012.94856).
23. Joynt KE, Jha AK. A path forward on Medicare readmissions. *N Engl J Med*. 2013;368:1175–7. doi:[10.1056/NEJMp1300122](https://doi.org/10.1056/NEJMp1300122).
24. Desai AS, Stevenson LW. Rehospitalisation for heart failure: predict or prevent? *Circulation*. 2012. doi:[10.1161/CIRCULATIONAHA.112.125435](https://doi.org/10.1161/CIRCULATIONAHA.112.125435).
25. Millett C, Majeed A, Saxena S, Lavery A, Alshamsan R, Lee J, et al. Impact of the 2004 General Practitioner Contract on health improvement and inequalities in cardiovascular disease and diabetes: findings from a systematic review and national and local quantitative studies. NIHR Service Delivery and Organisation Programme. Published June 2011. http://www.nets.nihr.ac.uk/__data/assets/pdf_file/0007/82393/ES-08-1716-209.pdf.

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