

Community healthcare professionals overestimate the risk of fatal anaphylaxis for food allergic children

H. J. Hanna, J. Emmanuel, S. Naim, T. Umasunthar and R. J. Boyle

Department of Paediatric Allergy, Imperial College London, London, UK

Clinical & Experimental Allergy

Summary

Background Fatal food anaphylaxis is rare, but a major concern for people with food allergy and their carers. We evaluated whether community healthcare professionals accurately estimate risk of fatal anaphylaxis for food allergic children, and whether accurate risk estimation is related to competence in recognizing and managing anaphylaxis.

Methods We enrolled 90 community healthcare professionals in a cross-sectional survey – 30 primary care nurses, 30 school first aiders, 30 community pharmacists. Participant risk estimates for fatal and non-fatal anaphylaxis, and all-cause fatalities, were measured using a risk ladder. Participant anaphylaxis knowledge was assessed by questionnaire, and practical skills using a simulated anaphylaxis scenario.

Results In all three groups, participants significantly overestimated the risk of fatal anaphylaxis for food allergic children, by a mean factor of 13.5-fold (95% CI 5.0, 31.6), but did not overestimate non-fatal anaphylaxis risk or all-cause fatality risk. We found no evidence of a relationship between successful adrenaline administration and risk estimation.

Conclusions and Clinical Relevance In conclusion, we have found evidence that community pharmacists, school first aiders and primary care nurses in the UK systematically overestimate the risk of fatal anaphylaxis for a food allergic child. This overestimation may result in increased patient and carer anxiety. Community practitioners who manage childhood food allergy and anaphylaxis need to be educated about the level of risk for fatal anaphylaxis in such children.

Keywords adrenaline auto-injector, anaphylaxis, food allergy, risk estimation

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Correspondence:

Dr Robert J. Boyle, Section of Paediatrics, Wright Fleming Building, Norfolk Place, London W2 1PG, UK.
E-mail: r.boyle@imperial.ac.uk

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Introduction

Food allergy is a common chronic condition with a significant effect on quality of life due to the dietary and social restrictions [1, 2] and is the commonest cause of anaphylaxis and fatal anaphylaxis in childhood [3]. It is associated with increased anxiety and stress, especially in mothers of food allergic children, in part due to the potential for fatal outcome [1, 2, 4, 5]. The risk of fatal anaphylaxis in a food allergic person is much lower than their risk of accidental death from other causes, yet the possibility of this rare but catastrophic event is a major focus for patients, carers and healthcare professionals dealing with food allergy [4, 6, 7].

Until recently, the precise level of risk for children with food allergy was not clear; however, our recent systematic reviews have now quantified the risk of fatal

or non-fatal anaphylaxis for a food allergic child and confirmed the risk to be low – for fatal anaphylaxis approximately 3 micromorts (events per million person years) in food allergic people aged 0–19 [8, 9].

If healthcare professionals over or underestimate this risk, this may influence their behaviour [10]. Moreover, any misconception may be passed on to food allergic children and their parents, resulting in overly protective behaviour with excess anxiety where risk is overestimated, or overly risk-taking behaviour where risk is underestimated, both of which may be detrimental to quality of life [11, 12].

To understand whether there is a systematic under or over estimation of fatal anaphylaxis risk for young people with food allergy, we undertook a cross-sectional survey of community healthcare professionals to quantify their risk estimates, as risk estimation is known to

influence behaviour. We also evaluated whether accuracy of participant risk estimates was related to their knowledge or skill in recognition and management of anaphylaxis, as excessively low- or high-risk estimations may be associated with overly risk-taking or cautious behaviour, respectively. The aims of this study were to examine the ability of community healthcare practitioners to (i) accurately estimate the risk of fatal anaphylaxis in food allergic children, (ii) examine their ability to treat anaphylaxis occurring in the community and (iii) establish whether there was a correlation between the two.

Methods

This study was a cross-sectional survey of community practitioners in the United Kingdom (UK) undertaken between November 2011 and April 2013 in the London borough of Westminster and rural Berkshire.

Participants

Thirty schools, 30 pharmacies and 30 General Practitioner (GP) practices, equally split between urban and rural settings, were approached from a list of all of the available schools, pharmacies and GP practices in the areas and were carefully selected to give a representative sample (e.g. A mix of junior and senior schools, a

mix of private and chain pharmacies). Inclusion criteria were as follows: designated school first aiders, whether or not they had a nursing qualification; qualified pharmacists and primary care practice nurses who were able and willing to participate in the research with freely given informed consent. Exclusion criteria were as follows: individuals who were regional expert trainers for other health care professionals in the treatment of anaphylaxis.

Risk estimation

Participants completed risk ladders (Fig. 1) [13], to assess their estimation of the likelihood of anaphylaxis, fatal anaphylaxis or death from any cause, for a food allergic child. Participants were asked to estimate three risks – ‘The chance of an “x” year old child dying in the next year due to any cause’; ‘The chance of an “x” year old peanut allergic child having a severe but non-fatal anaphylactic reaction in the next year’ and ‘The chance of an “x” year old peanut allergic child dying from an anaphylactic reaction in the next year’. Almost all participants were asked about risks for an 8-year old. For school first aiders working in a secondary school (ages 11–18), participants were asked about risks for a 15-year old. Separate comparator risks were acquired from public databases for 8- [5–9] and 15 [10–19]-year-old children for analysis [8].

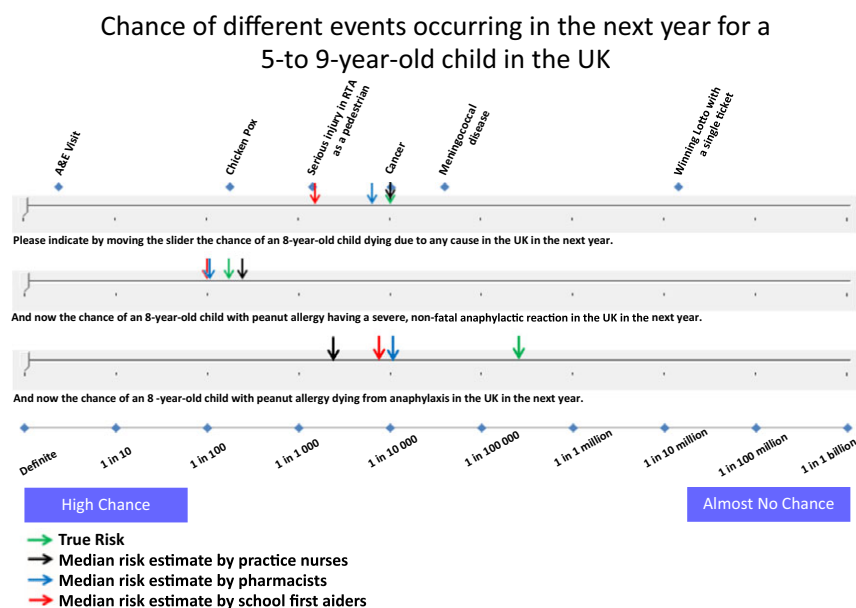


Fig. 1. Risk estimation tool. Participants were asked to indicate the likelihood of different events occurring, using this visual analogue scale. Reference risks derived from public health data sets are shown to orientate participants and were explained by the researcher. Modified versions of this tool were used for different age groups. Superimposed on the risk estimation tool are the median values for responses given by the three groups studied – practice nurses (black arrows), community pharmacists (blue arrows) and school first aiders (red arrows) – together with the true risks (green arrows) derived from the systematic reviews of Umasunthar et al.

Other study assessments

Following assessment of risk estimates, a questionnaire was completed by study participants – demographic information, anaphylaxis knowledge, previous allergy and adrenaline auto-injector (AAI) experience were evaluated as well as the self-ratings of confidence and ease of use of the AAI, measured using a 10-point Likert scale [14]. To evaluate indications for using AAI, a 16-item list was included in the questionnaire which can be summarized as ‘breathing difficulties, consciousness issues, gastrointestinal symptoms and skin symptoms’ from which the participants could select any or all of them as a symptom for which they would use the AAI.

Practical and written scenario-based questionnaires were then completed (Appendices S1 and S2). The practical anaphylaxis assessment required participants to demonstrate correct AAI technique in a simulated anaphylaxis scenario using a child-sized dummy with self-chosen auto-injector trainer pens (97% chose EpiPen). The criteria for anaphylaxis followed the UK resuscitation council guidelines (2012) – the symptoms occur suddenly and progress rapidly with life-threatening breathing and/or cardiovascular compromise, which may also encompass skin and gastrointestinal changes [15]. The written scenarios, which described children with (i) a non-anaphylactic food allergic reaction and (ii) an anaphylactic food allergic reaction, were administered, and participants were asked specific questions about management of these scenarios [14]. All data were completed by direct entry into a custom-made electronic clinical database (Dragonfly IT, Reading, UK).

Ethics and statistics

All study participants gave written informed consent, and the study was approved by a local NHS Research Ethics Committee (REC number 11/LO/0984) and the Imperial College Joint Research Office. Data distributions were visually inspected using histograms, and log-transformed where appropriate. Parametric continuous data were analysed using *t*-tests, and nonparametric

data using Mann–Whitney *U*-test or Wilcoxon signed rank test as appropriate. All analyses were made using SPSS v20 (IBM, Armonk, New York, USA), and *P*-values < 0.05 were considered significant. We did not make formal adjustments for multiple testing, but carefully considered the effect of multiple testing in our interpretation of findings [16].

Results

Thirty schools, 30 pharmacies and 30 GP practices agreed to participate in the research over an 18-month period from November 2011 to April 2013. Characteristics of sites and study participants are summarized in Tables S1 and 1, respectively. First aiders and practice nurses were almost all female, and 50% of pharmacists were female. Half of participants reported a personal experience of allergic disease, and most were experienced with median 12 years working in their field overall.

Risk perception in study participants

Table 2 shows study participants' estimates of different risks for a child in the UK, acquired using the risk ladder shown in Fig. 1. Participants did not systematically overestimate a child's risk for all-cause fatality or their overall anaphylaxis risk; however, all three study groups significantly overestimated fatal anaphylaxis risk for a food allergic child by an overall mean factor of $\log_{10}$ 1.13 (95% CI 0.77, 1.50) or mean 13.5-fold (95% CI 5.0, 31.6-fold). This overestimation was significantly greater than any overestimation of all-cause mortality risk – mean difference $\log_{10}$ 0.87 (95% CI 0.49, 1.26; *P* < 0.001).

Ability and confidence to administer adrenaline

Just 22% of participants had used an AAI device before (Table 3). Participants generally felt confident they knew *when* to use the injector although many incorrectly thought it should be used for gastrointestinal (12%) or skin (47%) symptoms alone. Participants felt confident in

Table 1. Participant demographic information

Participant information	School first aiders <i>n/N</i> (%) or median (IQR)	Pharmacists <i>n/N</i> (%) or median (IQR)	GP surgery practice nurses <i>n/N</i> (%) or median (IQR)	Total <i>n/N</i> (%) or median (IQR)
Female gender	29/30 (97%)	15/30 (50%)	30/30 (100%)	74/90 (82%)
Age over 45	13/30 (43%)	9/30 (30%)	23/30 (77%)	45/90 (50%)
University degree	20/30 (67%)	26/30 (87%)	14/30 (47%)	60/90 (67%)
Personal experience of allergy	16/30 (53%)	16/30 (53%)	15/30 (50%)	47/90 (52%)
Professional experience of allergy	3/30 (10%)	11/30 (37%)	9/30 (30%)	23/90 (26%)
Number of years in occupation	10 (7, 17)	7 (3, 25)	15 (9, 23)	12 (5, 21)
Accessed anaphylaxis campaign website	8/30 (27%)	3/30 (10%)	6/30 (20%)	17/90 (19%)

GP, General Practitioner.

Table 2. Study participants' risk estimates for any fatality, anaphylaxis and fatal anaphylaxis in a peanut allergic child

	School first aiders*	Pharmacists	GP practice nurses	Total
All-cause fatality risk	3.18 (2.38, 3.74)	3.73 (2.89, 4.77)	3.99 (3.00, 5.37)	3.43 (2.87, 4.66)
Overestimation of this risk [†]	0.55 (0.06, 1.03)	0.34 (−0.26, 0.95)	−0.11 (−0.77, 0.55)	0.26 (−0.07, 0.59)
P-value	0.03	0.26	0.74	0.12
Severe anaphylaxis risk	1.99 (1.01, 3.14)	2.02 (1.19, 3.98)	2.38 (1.98, 3.65)	2.02 (1.32, 3.53)
Overestimation of this risk [†]	0.36 (−0.37, 1.09)	0.31 (−0.30, 0.91)	−0.28 (−0.97, 0.41)	0.13 (−0.25, 0.51)
P-value	0.32	0.31	0.41	0.50
Fatal anaphylaxis risk	3.86 (2.96, 5.00)	4.02 (2.99, 5.02)	3.36 (2.75, 5.00)	4.00 (2.98, 5.01)
Overestimation of this risk [†]	1.32 (0.64, 2.00)	1.03 (0.50, 1.55)	1.06 (0.30, 1.81)	1.13 (0.77, 1.50)
P-value	< 0.001	< 0.001	0.008	< 0.001

GP, General Practitioner.

Data represent log₁₀ transformed probability estimates for different events, derived using the risk estimation tool shown in Fig. 1.

*Sensitivity analysis excluding the school first aiders who were qualified nurses (*n* = 7) showed similar findings, with overestimation of all-cause fatality (*P* = 0.04), no overestimation of severe anaphylaxis risk (*P* = 0.54) and significant overestimation of fatal anaphylaxis risk (1.09; 95% CI 0.28, 1.91; *P* = 0.01).

[†]Data for overestimates are parametric, so are presented as mean (95% CI) and are compared with published risks using the one-sample *t*-test. Other data are nonparametric, so are presented as median (IQR).

Table 3. Participants' ability and confidence to treat anaphylaxis

	School first aiders <i>n/N</i> (%) or median (IQR)	Pharmacists <i>n/N</i> (%) or median (IQR)	GP practice nurses <i>n/N</i> (%) or median (IQR)	Total <i>n/N</i> (%) or median (IQR)
Previous use of AAI	7/30 (23%)	4/30 (13%)	9/30 (30%)	20/90 (22%)
Confidence* when to use AAI	8 (7, 9)	7 (6, 8)	8 (6, 8)	7.5 (6, 8)
Indications to use AAI				
Breathing difficulties	28/30 (93%)	28/30 (93%)	30/30 (100%)	86/90 (96%)
Consciousness issues	25/30 (83%)	21/30 (70%)	29/30 (97%)	75/90 (83%)
Gastrointestinal symptoms	5/30 (17%)	4/30 (13%)	2/30 (7%)	11/90 (12%)
Skin symptoms	12/30 (40%)	6/30 (20%)	24/30 (80%)	42/90 (47%)
Confidence* in how to use AAI	9 (8, 10)	8 (7, 8)	9 (7, 9)	8 (7, 9)
AAI used				
EpiPen®	29/30 (97%)	28/30 (93%)	30/30 (100%)	87/90 (97%)
Other AAI	1/30 (3%)	2/30 (7%)	0/30 (0%)	3/90 (3%)
Successful adrenaline delivery	20/30 (67%)	12/30 (40%)	5/30 (17%)	37/90 (41%)
Time to injection (seconds)	53 (35, 87)	28 (13, 38)	26 (14, 40)	31 (18, 53)
Emergency services called	25/30 (83%)	19/30 (63%)	22/30 (73%)	66/90 (73%)
Adverse event (digital injection)	2/30 (7%)	1/30 (3%)	5/30 (17%)	8/90 (9%)
Primary reason for AAI failure				
Failure to remove safety caps	4/30 (13%)	5/30 (17%)	1/30 (3%)	10/90 (11%)
Incorrect end	4/30 (13%)	0/30 (0%)	6/30 (20%)	10/90 (11%)
Device not activated	0/30 (0%)	5/30 (17%)	2/30 (7%)	7/90 (8%)
Held in place < 5 s	2/30 (7%)	8/30 (26%)	16/30 (53%)	26/90 (29%)

AAI, adrenaline auto-injector; GP, General Practitioner.

*Likert scale where 1 = not confident and 10 = completely confident.

how to use the AAI, but success rates in the anaphylaxis scenario were low (41%) and a small number would have self-injected digitally. The most common reasons for failure were not holding the AAI in place for 5 s, failure to remove the safety cap, using the incorrect end to inject and not activating the device.

Knowledge of anaphylaxis management

From Table 4, it can be seen that 21% of participants would have used the AAI in a non-anaphylactic

situation, 26% would have used a Beta-2 agonist inhaler, and 33% called an ambulance. These measures were not considered necessary in the non-anaphylactic allergic reaction presented. When presented with an anaphylaxis scenario, 72% of participants stated they would call an ambulance and 76% would use an AAI, but only 53% used an AAI as a first action. These responses differ from those to the non-scenario-based questions shown in Table 3, where 47% would use an AAI for skin symptoms alone, and 12% for gastrointestinal symptoms alone.

Table 4. Knowledge of how to treat allergic reactions

	School first aiders <i>n/N (%)</i>	Pharmacists <i>n/N (%)</i>	GP practice nurses <i>n/N (%)</i>	Total <i>n/N (%)</i>
Non-anaphylactic reaction				
AAI administration	4/30 (13)	9/30 (30)	6/30 (20)	19/90 (21)
Beta-2 agonist inhalation	7/30 (23)	6/30 (20)	10/30 (33)	23/90 (26)
Antihistamines	29/30 (97)	21/30 (70)	26/30 (87)	76/90 (84)
Call an ambulance	8/30 (27)	10/30 (33)	12/30 (40)	30/90 (33)
Call the child's parents	28/30 (93)	28/30 (93)	29/30 (97)	85/90 (94)
Anaphylactic reaction				
AAI administration	20/30 (67)	23/30 (77)	25/30 (83)	68/90 (76)
As first action	12/30 (40)	16/30 (53)	20/30 (67)	48/90 (53)
Beta-2 agonist inhalation	24/30 (80)	20/30 (67)	19/30 (63)	63/90 (70)
As first action	10/30 (33)	5/30 (17)	3/30 (10)	18/90 (20)
Antihistamines	21/30 (70)	18/30 (60)	18/30 (60)	57/90 (63)
As first action	6/30 (20)	6/30 (20)	4/30 (13)	16/90 (18)
Call an ambulance	22/30 (73)	20/30 (67)	23/30 (77)	65/90 (72)
As first action	2/30 (7)	2/30 (7)	2/30 (7)	6/90 (7)
Call the child's parents	29/30 (97)	29/30 (97)	29/30 (97)	87/90 (97)

AAI, adrenaline auto-injector; GP, General Practitioner.

Risk estimation and management of anaphylaxis

The relationship between risk estimates and participants' ability to administer adrenaline are shown in Table 5 and show no significant differences between those who successfully administered adrenaline and those who did not. Table S2 shows the relationship between risk estimates and participants' actions in a theoretical anaphylaxis scenario. There was no consistent relationship between risk estimates and knowledge of how to recognize/treat anaphylaxis. Similarly (Table S3), we found no consistent evidence for a relationship between risk estimates and recognition that AAI is the first step for treatment of anaphylaxis. We found no evidence that calling an ambulance as part of anaphylaxis management was associated with risk estimates (Table S4).

Risk estimation and management of a non-anaphylactic allergic reaction

We also evaluated the relationship between risk estimation and theoretical management of a non-anaphylactic allergic reaction. Overall, participants who indicated they would call an ambulance as part of management of a non-anaphylactic allergic reaction overestimated all risks as significantly higher than participants who

(correctly) would not call an ambulance for such reactions. However, there was some inconsistency between the three participant groups in these differences (Table S5). We found no consistent evidence for a relationship between administration of AAI as part of management of a non-anaphylactic allergic reaction and risk estimates (Table S6).

Discussion

In this cross-sectional study of community healthcare practitioners, we had three main findings. First, we found that the risk of fatal anaphylaxis for a food allergic child is significantly overestimated, whereas this was not the case for all-cause fatality or non-fatal anaphylaxis risks. Second, and consistent with previous studies [13, 17], we found that most participants were unable to successfully administer an AAI in a simulated anaphylaxis scenario. Third, we did not find any consistent evidence that overestimation of these risks is associated with improved ability to treat anaphylaxis, either when presented as a theoretical or practical scenario. These data suggest that the overestimation of risk is not helpful as this may result in an increase in patient and carer anxiety, reducing their quality of life and potentially resulting in restrictions being placed on the child's activities [11, 12, 18]. These findings also suggest that information about fatal anaphylaxis risk should be incorporated into anaphylaxis training packages.

The systematic overestimation of fatal food anaphylaxis risk, which we found in this context, is consistent with evidence for other rare, catastrophic events which are often perceived as more probable than the reality [4, 19]. Excessive media and medical attention to cases of fatal food anaphylaxis may also contribute to the perception that this outcome is more likely to occur than the reality [20–22]. Despite the rarity of fatal food anaphylaxis, the possibility of this catastrophic outcome plays an important part in the personal, professional and public dialogue surrounding food allergy [2, 5, 23, 24]. In the context of food allergy, where anxiety, stress and social exclusion are a significant part of the disease burden [7], it is possible that overestimation of risks by community practitioners may increase or reinforce such feelings and behaviours. Equally, it is possible that overestimation of risks may lead to heightened awareness, information-seeking and practical ability in the management of allergic reactions.

In this study, we did not find any evidence that overestimation of allergy or fatality risks is associated with improved ability to administer AAI, or improved knowledge of how to treat anaphylactic or non-anaphylactic allergic reactions. Indeed, we found some evidence for an association between overestimation of risks and

Table 5. Relationship between risk estimates and ability to administer AAI

	School first aiders Median (IQR)	Pharmacists Median (IQR)	GP practice nurses Median (IQR)	Total Median (IQR)
Overestimation of overall fatality risk				
Successful adrenaline administration	0.34 (−0.73, 0.98)	0.79 (−0.37, 1.13)	0.03 (−1.99, 0.45)	0.31 (−0.27, 1.03)
Unsuccessful adrenaline administration	0.77 (0.21, 1.66)	0.02 (−1.42, 1.19)	0.06 (−1.54, 1.12)	0.50 (−1.09, 1.28)
P-value	0.40	0.46	0.48	0.73
Overestimation of anaphylaxis risk				
Successful adrenaline administration	0.80 (−0.23, 1.76)	0.77 (−0.62, 1.73)	0.76 (−0.24, 1.13)	0.78 (−0.23, 1.70)
Unsuccessful adrenaline administration	0.78 (−0.89, 1.85)	0.77 (−1.22, 1.53)	−0.21 (−0.98, 0.81)	0.75 (−1.21, 0.82)
P-value	0.95	0.64	0.45	0.16
Overestimation of fatal anaphylaxis risk				
Successful adrenaline administration	1.15 (0.17, 2.23)	1.80 (0.30, 2.43)	2.04 (1.44, 3.06)	1.51 (0.29, 2.42)
Unsuccessful adrenaline administration	1.58 (0.18, 2.09)	0.26 (0.00, 1.19)	1.07 (0.05, 2.10)	1.03 (0.35, 2.07)
P-value	0.83	0.09	0.25	0.13

AAI, adrenaline auto-injector; GP, General Practitioner.

Data represent log₁₀ transformed probability estimates for different events, derived using the risk estimation tool shown in Fig. 1.

Data for overestimates were compared between groups using Mann–Whitney *U*-test.

over-treatment of non-anaphylactic reactions. This suggests that accurate information about the risks associated with food allergy can be safely included in routine information leaflets and training packages for professionals and patients affected by food allergy [3].

Overall we found that community practitioners were not well prepared for managing food allergic reactions. Only 41% of participants successfully administered an AAI in the practical scenario – one-third would call an ambulance, and one-fifth would give AAI, for a non-anaphylactic food allergic reaction, and just half would give an AAI as the first-line treatment of anaphylaxis. Similar numbers would give beta-2 agonists to treat anaphylaxis, but only 20% responded that these should be first-line anaphylaxis treatment. These data are consistent with previous findings that knowledge of how to use an AAI is low in patients and healthcare professionals [17, 25–27]. Furthermore, there is confusion about what constitutes anaphylaxis [13, 14] and in the early days of food-related anaphylaxis management some professionals recommended that cutaneous symptoms such as rash and facial swelling required treatment with adrenaline [28]. School age children have relatively high rates of food anaphylaxis compared to other groups [23], and it is thought that outcomes of serious reactions may be worse when they occur at school as opposed to occurring at home [29]. As 17–20% of food allergic reactions occur in schools [23, 30], first aiders have an important role in the support, education and practical evaluation and treatment of food allergic children and young people. Our study demonstrates that school first aiders may not be adequately prepared to recognize and manage anaphylaxis, and emphasizes their need for further training [23, 25, 31]. Practice nurses had a particularly low (17%) success rate with AAI, despite relatively high knowledge scores, and

demonstrated unfamiliarity with AAI administration, having the highest digital injection rate and often not holding the AAI in place for 5 s. There was a feeling in all groups that the family should be trained by ‘someone else’, either a hospital-based clinic or one of the other groups surveyed. Our study findings suggest that all practitioners who are involved in the dispensing, training and use of AAI’s in the community should have regular, mandatory and prescribed training – available in the UK through the Anaphylaxis Campaign’s ‘Allergywise’ training for healthcare professionals including pharmacists [32].

Our study has some limitations – first, the levels of risk identified by our previous systematic review are an estimate and rely on accurate coding of cause of death/hospital attendance – however, these are the most accurate figures currently available, and studies have failed to confirm that under-recognition of fatal food anaphylaxis is prevalent [33]. Second, this study assessed relatively small numbers of participants so although it is clear that fatal anaphylaxis risk is overestimated, some of the other comparisons would need larger study numbers for confident interpretation. Third, we did not report risk perception in other important stakeholders such as parents – these data were gathered as part of a separate clinical trial and will be reported with the trial outcomes (www.controlled-trials.com/ISRCTN12504076). Fourth, the risk ladder designed for this study has not been explicitly validated in this setting; however, risk ladders are used widely in risk communication studies in other settings [34] and the fact that we saw clear relationships suggests that the risk ladders are an effective measurement tool. Of particular note, the findings here are specific to the scenario used – that is a young person with peanut allergy – and it is possible that findings

may differ for allergy to other foods, or in different age groups – this is a subject for further study. Finally, we did not formally adjust for multiple testing in this study, although our key findings were consistent across three different study populations.

In conclusion, we have found evidence that community pharmacists, school first aiders and primary care nurses in the UK systematically overestimate the risk of fatal anaphylaxis for a food allergic child. This overestimation is not helpful for management of such children. Information about the level of risk of fatal or non-fatal anaphylaxis should be included in more comprehensive educational packages for community practitioners who manage childhood food allergy and anaphylaxis.

References

- Akeson N, Worth A, Sheikh A. The psychosocial impact of anaphylaxis on young people and their parents. *Clin Exp Allergy* 2007; **37**:1213–20.
- Mandell D, Curtis R, Gold M, Hardie S. Anaphylaxis: how do you live with it? *Health Soc Work* 2005; **30**:325–35.
- Boyce JA, Assa'ad A, Burks AW, *et al*. Guidelines for the diagnosis and management of food allergy in the United States: report of the NIAID-sponsored expert panel. *J Allergy Clin Immunol* 2010; **126**:1–58.
- Lau GY, Patel N, Umasunthar T *et al*. Anxiety and stress in mothers of food-allergic children. *Pediatr Allergy Immunol* 2014; **25**:236–42.
- Gillespie CA, Woodgate RL, Chalmers KI, Watson WT. "Living with risk": mothering a child with food-induced anaphylaxis. *J Pediatr Nurs* 2007; **22**:30–42.
- de Silva IL, Mehr SS, Tey D, Tang ML. Paediatric anaphylaxis: a 5 year retrospective review. *Allergy* 2008; **63**:1071–6.
- Avery NJ, King RM, Knight S, Hourihane JO. Assessment of quality of life in children with peanut allergy. *Pediatr Allergy Immunol* 2003; **14**:378–82.
- Umasunthar T, Leonardi-Bee J, Hodes M *et al*. Incidence of fatal food anaphylaxis in people with food allergy: a systematic review and meta-analysis. *Clin Exp Allergy* 2013; **43**:1333–41.
- Turner PJ, Boyle RJ. Food allergy in children: what is new? *Curr Opin Clin Nutr Metab Care* 2014; **17**:285–93.
- Eiser JR, Bostrom AIB, Burton I *et al*. Risk interpretation and action: a conceptual framework for responses to natural hazards. *Int J Disaster Risk Reduct* 2012; **1**:5–16.
- Knibb RC, Barnes C, Stalker C. Parental self-efficacy in managing food allergy and mental health predicts food allergy-related quality of life. *Pediatr Allergy Immunol* 2016; **27**:459–64.
- DunnGalvin A, Chang WC, Laubach S *et al*. Profiling families enrolled in food allergy immunotherapy studies. *Pediatrics* 2009; **124**:e503–9.
- Umasunthar T, Proctor A, Hodes M *et al*. Patients' ability to treat anaphylaxis using adrenaline autoinjectors: a randomized controlled trial. *Allergy* 2015; **70**:855–63.
- Noimark L, Wales J, Du Toit G *et al*. The use of adrenaline autoinjectors by children and teenagers. *Clin Exp Allergy* 2012; **42**:284–92.
- Resuscitation Council UK. *Emergency treatment of anaphylactic reactions. Guidelines for healthcare providers*. Resuscitation Council UK, 2012. Available from <https://www.resus.org.uk/anaphylaxis/emergency-treatment-of-anaphylactic-reactions/>.
- Perneger TV. What's wrong with Bonferroni adjustments. *BMJ* 1998; **316**:1236–8.
- Mehr S, Robinson M, Tang M. Doctor–how do I use my EpiPen? *Pediatr Allergy Immunol* 2007; **18**:448–52.
- Ropeik D. The consequences of fear. *EMBO Rep* 2004; **5**:S56–60.
- Ropeik D. Never bitten twice shy. *New York Times*, August 9 2003.
- Christakis NA. This allergies hysteria is just nuts. *BMJ* 2008; **337**:a2880.
- Ropeik D. How society should respond to the risk of vaccine rejection. *Hum Vaccin Immunother* 2013; **9**:1815–8.
- Wahlberg A, Sjöberg L. Risk perception and the media. *J Risk Res* 2000; **3**:31–50.
- Muraro A, Clark A, Beyer K *et al*. The management of the allergic child at school: EAACI/GA2LEN Task Force on the allergic child at school. *Allergy* 2010; **65**:681–9.
- Sampson MA, Munoz-Furlong A, Sicherer SH. Risk-taking and coping strategies of adolescents and young adults with food allergy. *J Allergy Clin Immunol* 2006; **117**:1440–5.
- Russell S, Monroe K, Losek JD. Anaphylaxis management in the pediatric emergency department: opportunities for improvement. *Pediatr Emerg Care* 2010; **26**:71–6.
- McLean-Tooke AP, Bethune CA, Fay AC, Spickett GP. Adrenaline in the treatment of anaphylaxis: what is the evidence? *BMJ* 2003; **327**:1332–5.
- Lieberman P. Use of epinephrine in the treatment of anaphylaxis. *Curr Opin Allergy Clin Immunol* 2003; **3**:313–8.
- Sampson HA, Mendelson L, Rosen JP. Fatal and near-fatal anaphylactic reactions to food in children and adolescents. *N Engl J Med* 1992; **327**:380–4.
- Frost DW, Chalin CG. The effect of income on anaphylaxis preparation and management plans in Toronto primary schools. *Can J Public Health* 2005; **96**:250–3.
- Turner PJ, Gowland MH, Sharma V *et al*. Increase in anaphylaxis-related hospitalizations but no increase in

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The authors declare no conflict of interest.

- fatalities: an analysis of United Kingdom national anaphylaxis data, 1992–2012. *J Allergy Clin Immunol* 2015; 135:956–63.e1.
- 31 Gold MS, Sainsbury R. First aid anaphylaxis management in children who were prescribed an epinephrine autoinjector device (EpiPen). *J Allergy Clin Immunol* 2000; 106(1 Pt 1): 171–6.
- 32 The Anaphylaxis Campaign. Allergy-wise training. Available from www.anaphylaxis.org.uk/information-resources/allergwise-training.
- 33 Pumphrey RS, Gowland MH. Further fatal allergic reactions to food in the United Kingdom, 1999–2006. *J Allergy Clin Immunol* 2007; 119:1018–9.
- 34 Sjoberg L. Factors in risk perception. *Risk Anal* 2000; 20:1–11.

Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Workplace information for schools and GP practices.

Table S2. Relationship between risk estimates and knowledge of anaphylaxis treatment (whether AAI* given).

Table S3. Relationship between risk estimates and knowledge of anaphylaxis treatment (whether adrenaline given as first step).

Table S4. Relationship between risk estimates and knowledge of anaphylaxis treatment (whether ambulance called).

Table S5. Relationship between risk estimates and knowledge of non-anaphylactic reaction treatment (whether ambulance called).

Table S6. Relationship between risk estimates and knowledge of non-anaphylactic reaction treatment (whether AAI* given).

Appendix S1. Scenarios questionnaire.

Appendix S2. Scoring system for demonstration of autoinjector.

Title Page - Supplementary files

Community-based healthcare professionals overestimate the risk of fatal anaphylaxis for food
allergic children

Heather J Hanna MSc, Josephine Emmanuel BSc, Sarah Naim BSc, Thisayanagam

Umasunthar MB ChB, Robert J Boyle MB ChB, PhD

Imperial College, London, UK

Running title - Risk estimation in childhood food allergy

Correspondence to Dr Robert Boyle, Section of Paediatrics,

Wright Fleming Building, Norfolk Place, London W2 1PG, UK

Tel. +44 207 594 3990

Fax. +44 207 594 3984

r.boyle@imperial.ac.uk

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Appendix S1: Scenarios Questionnaire



Questionnaire to Evaluate Knowledge and Confidence of Healthcare Providers Regarding Allergy Management.

Study # _____ Name of school _____ Date _____

Healthcare provider to complete										
	Not at all confident					Extremely confident				
	1	2	3	4	5	6	7	8	9	10
How confident are you that you know when to use the child's adrenaline auto injector	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Not at all easy					Extremely easy				
Please indicate how easy it is to use the child's adrenaline auto injector?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

I am going to read a scenario to you and using the manikin and a child's emergency medication box, please demonstrate the steps you would take to make the child better, and to get help. Do not actually administer any drugs, but describe how you would do this. I will then substitute the adrenaline auto injector for a trainer injector pen for the demonstration. **Please show me exactly what you would do, imagining as far as possible that this is a real life situation.**

Instructions to the research nurse/doctor:

- 1) Please complete all questionnaires prior to scenario test above.
- 2) Use an appropriate manikin similar size to the child.
- 3) Please place the manikin in a chair in a **seated** position prior to recording scenario.
- 4) Please have the allocated trainer adrenaline auto injector readily available for the healthcare provider
- 5) Please place a telephone in a readily visible place.
- 6) **Please switch the wheezing noise on when you say go.**
- 7) At the end of the demonstration ask whether there is anything else that the participant would like to do, and ask what they would do with the adrenaline auto injector regarding disposal.
- 8) Please complete the scoring system for demonstration of either Anapen or EpiPen.
- 9) Ask the healthcare provider to repeat the adrenaline auto injector with the alternative device, if it is used in their school.
- 10) Please provide any feedback **after** the demonstration, scoring and recording have finished. Please ensure they know how to use the adrenaline auto injector correctly, before they leave the session.

Scenario 1

You are out on a school trip to a museum. All the children are eating their packed lunch and you notice that Michael (who has an egg, soya and nut allergy) is rubbing his face and has started to develop hives around his face and neck. Five minutes later he is pale, drowsy and is having trouble breathing. **Please show me exactly what you would do, imagining as far as possible that this is a real life situation.**

Score actions from scenario 1 and use of trainer pen using next sheet.

Please complete the questions for the following 2 scenarios

Scenario 2

Edward has a cow's milk allergy he is in year 7. Its break time and you notice his face is looking red and blotchy. When you go over to him, you see hives around his mouth and eyes. He is beginning to scratch his neck. He has some antihistamine syrup and two adrenaline injectors in his medicine box.

What will you do?

- | | | |
|--|------------------------------|-----------------------------|
| 1. Give him his adrenaline injector? | ☐ Yes | ☐ No |
| 2. Watch him carefully but do not give any medication? | ☐ Yes | ☐ No |
| 3. Give him the blue inhaler? | ☐ Yes | ☐ No |
| 4. Give him the antihistamine medicine? | ☐ Yes | ☐ No |
| 5. Call an ambulance? | ☐ Yes | ☐ No |
| 6. Call his parent/carer? | ☐ Yes | ☐ No |

Scenario 3

Ashanti is allergic to egg and nuts, she is in year 8. It's another pupil's birthday and there is some cake. You have a nut free policy at the school. Ashanti has her own safe cake to eat but she says she feels sick. Her lips appear a little swollen and she is looking pale. She says that her breathing hurts. She has antihistamine syrup, two adrenaline injectors and a blue inhaler in her medicine box.

What will you do?

- | | | |
|--|------------------------------|-----------------------------|
| 1. Give her the antihistamine medicine? | ☐ Yes | ☐ No |
| 2. Watch him carefully but do not give any medication? | ☐ Yes | ☐ No |
| 3. Give her the blue inhaler? | ☐ Yes | ☐ No |
| 4. Give her the adrenaline injector? | ☐ Yes | ☐ No |
| 5. Call an ambulance? | ☐ Yes | ☐ No |
| 6. Call her parent/carer? | ☐ Yes | ☐ No |

Thank you for taking the time to complete this questionnaire.

Appendix S2: Scoring System for Demonstration of Autoinjector

Scoring System for Demonstration of Autoinjector

Epipen	Yes	No	Anapen	Yes	No
Correctly identified device and checked that is was in date	☐	☐	Correctly identified device and checked that is was in date	☐	☐
Removal of Grey cap	☐	☐	Removal of Black needle cap	☐	☐
			Check for Grey rubber cap removal	☐	☐
			Removal of safety cap	☐	☐
Correct anatomical position	☐	☐	Correct anatomical position	☐	☐
Correct end to inject	☐	☐	Correct end to inject	☐	☐
Pressure or swing action to activate	☐	☐	Pressure applied at time of activation	☐	☐
Successful device activation	☐	☐	Successful device activation	☐	☐
Hold for 5 seconds	☐	☐	Hold for 5 seconds	☐	☐
Exact time autoinjector held in position after activation	_____		Exact time autoinjector held in position after activation	_____	
Massage the area	☐	☐	Massage the area	☐	☐
Correct disposal of needle	☐	☐	Correct disposal of needle	☐	☐
Adrenaline effectively administered	☐	☐	Adrenaline effectively administered	☐	☐
Adverse event (e.g. finger injection)	☐	☐	Adverse event (e.g. finger injection)	☐	☐
Details:					
Child kept in an appropriate position throughout the demonstration	☐	☐	Child kept in an appropriate position throughout the demonstration	☐	☐
Emergency services called, or participant stated that they would call them	☐	☐	Emergency services called, or participant stated that they would call them	☐	☐
Did the healthcare providers receive training? ☐ Yes ☐ No					

Table S1: Workplace Information for Schools and GP Practices

	Schools n/N (%)	Pharmacies n/N (%)	GP Practices n/N (%)
Urban	15/30 (50%)	15/30 (50%)	15/30 (50%)
Record of food allergic patients/pupils	29/30 (97%)	-	21/30 (70%)
Allergy management plan for affected pupils/patients	23/30 (77%)	-	20/30 (67%)
Number of autoinjectors	held at school per child	-	prescribed per child
One pen	14/30 (47%)		2/30 (7%)
Two pens	15/30 (50%)		18/30 (60%)
Three pens	1/30 (3%)		10/30 (33%)

Table S2: Relationship between Risk Estimates and Knowledge of anaphylaxis treatment (whether AAI* given)

Risk Estimates & Knowledge	School First Aiders Median (IQR)	Pharmacists Median (IQR)	GP Practice Nurses Median (IQR)	Total
Overestimation of overall fatality risk				
AAI not planned to be used (incorrect)	0.45 (-0.45,1.15)	-0.48 (-1.24, 0.02)	-1.97 (-2.83, 0.96)	0.05 (-1.97,0.83)
AAI used (correctly)	0.51 (-0.73,1.51)	1.01 (-0.41, 1.35)	0.40 (-0.96, 1.16)	0.52 (-0.52,1.31)
p Value	0.75	0.048	0.21	0.049
Overestimation of anaphylaxis risk				
AAI not planned to be used (incorrect)	0.78 (-1.18,1.78)	0.77 (0.10, 0.78)	0.75 (-2.07, 1.12)	0.77 (0.00,1.30)
AAI used (correctly)	0.80 (-0.21,1.70)	0.76 (-1.21, 1.79)	-0.21 (-0.98, 0.81)	0.76 (-1.21,1.53)
p Value	0.91	0.89	0.87	0.67
Overestimation of fatal anaphylaxis risk				
AAI not planned to be used (incorrect)	1.11 (0.77, 2.47)	0.40 (-0.72, 2.06)	1.44 (-1.21, 2.57)	1.06 (-0.20, 2.07)
AAI used (correctly)	1.50 (0.38, 2.15)	1.06 (0.70, 2.08)	1.96 (0.65, 2.47)	1.08 (0.06, 2.14)
p Value	0.91	0.19	0.83	0.47

*AAI = Adrenaline Auto-Injector

Table S3: Relationship between Risk Estimates and Knowledge of anaphylaxis treatment (whether adrenaline given as first step)

VAS	School First Aiders Median (IQR)	Pharmacists Median (IQR)	GP Practice Nurses Median (IQR)	Total
VAS 1 (any death) overestimation				
Correctly planned Adrenaline Administration as first step	0.54 (-0.63, 1.51)	1.03 (-0.18, 1.85)	0.41 (-0.88, 1.16)	0.81 (-0.29, 1.31)
Incorrectly did not plan first step Administer Adrenaline	0.41 (-0.73, 1.36)	-0.23 (-1.42, 0.64)	-1.41 (-3.05, 0.92)	0.55 (-1.42, 0.92)
p Value	0.69	0.038	0.061	0.05
VAS 2 (anaphylaxis) overestimation				
Correctly planned Adrenaline Administration as first step	0.73 (-1.18, 1.70)	0.78 (-0.11, 1.80)	0.26 (-1.08, 0.81)	0.76 (-0.74, 1.53)
Incorrectly did not plan first step Administer Adrenaline	0.80 (-0.21, 1.83)	0.43 (-1.22, 0.83)	0.41 (-1.62, 0.79)	0.77 (-0.86, 1.30)
p Value	0.39	0.26	0.91	0.97
VAS 3 (fatal anaphylaxis) overestimation				
Correctly planned Adrenaline Administration as first step	1.06 (-0.45, 1.99)	1.56 (0.57, 2.94)	1.52 (0.07, 2.84)	1.16 (0.73, 2.14)
Incorrectly did not plan first step Administer Adrenaline	1.76 (0.77, 2.48)	0.06 (-0.78, 1.06)	1.74 (-0.85, 2.27)	1.06 (-0.00, 2.07)
p Value	0.35	0.006	0.65	0.29

Table S4: Relationship between Risk Estimates and Knowledge of anaphylaxis treatment (whether ambulance called)

Risk Estimates & Knowledge	School First Aiders Median (IQR)	Pharmacists Median (IQR)	GP Practice Nurses Median (IQR)	Total
Overestimation of overall fatality risk				
Ambulance not called (incorrect)	0.68 (0.15,1.38)	0.20 (-1.20,1.12)	-1.97 (-3.21, 0.89)	0.80 (-1.61,1.02)
Ambulance called (correctly)	0.50 (-0.16,1.48)	0.95 (-0.56,1.30)	0.06 (-0.85, 1.20)	0.50 (-0.51,1.28)
p Value	0.60	0.56	0.03	0.16
Overestimation of anaphylaxis risk				
Ambulance not called (incorrect)	0.80 (0.04,1.77)	0.77 (-1.52,1.09)	0.07 (-0.75, 0.81)	0.77 (-0.64,1.21)
Ambulance called (correctly)	0.78 (-0.89,1.77)	0.77 (-1.09,1.79)	0.74 (-1.21, 0.80)	0.76 (-0.98,1.55)
p Value	0.84	0.68	0.92	0.96
Overestimation of fatal anaphylaxis risk				
Ambulance not called (incorrect)	1.34 (1.02,3.30)	0.07 (-0.76,1.70)	1.44 (-0.49, 3.03)	1.07 (-0.30,2.34)
Ambulance called (correctly)	1.15 (0.05,2.10)	1.06 (0.08,2.43)	1.96 (0.06, 2.10)	1.06 (0.60,2.09)
p Value	0.73	0.12	0.70	0.69

Table S5: Relationship between Risk Estimates and Knowledge of non-anaphylactic reaction treatment (whether ambulance called)

Risk Estimates & Knowledge	School First Aiders Median (IQR)	Pharmacists Median (IQR)	GP Practice Nurses Median (IQR)	Total
Overestimation of overall fatality risk				
Ambulance called unnecessarily	0.76 (0.53,1.95)	0.52 (-0.95,1.35)	1.03 (0.04, 2.05)	1.02 (0.02,2.02)
Ambulance not called (correctly)	0.51 (-0.16,1.14)	0.29 (-1.01,1.13)	-0.96 (-2.11, 0.78)	0.10 (-1.12,1.01)
p Value	0.48	0.91	<0.001	0.013
Overestimation of anaphylaxis risk				
Ambulance called unnecessarily	1.76 (0.92,2.33)	0.78 (-0.11,1.87)	0.75 (0.26, 0.80)	0.79 (0.14,1.77)
Ambulance not called (correctly)	0.72 (-1.51,1.59)	0.55 (-1.28,1.33)	-0.07 (-1.82, 0.82)	0.50 (-1.28,0.94)
p Value	0.007	0.29	0.55	0.025
Overestimation of fatal anaphylaxis risk				
Ambulance called unnecessarily	1.54 (0.04,2.15)	2.08 (0.82,3.19)	2.05 (0.32, 2.83)	2.05 (0.80,2.68)
Ambulance not called (correctly)	1.20 (0.39,2.12)	0.26 (-0.07,1.08)	0.94 (-0.85, 2.32)	1.05 (0.33,2.05)
p Value	1.00	0.017	0.16	0.027

Table S6: Relationship between Risk Estimates and Knowledge of non-anaphylactic reaction treatment (whether AAI* given)

Risk Estimates & Knowledge	School First Aiders Median (IQR)	Pharmacists Median (IQR)	GP Practice Nurses Median (IQR)	Total
Overestimation of overall fatality risk				
AAI planned to be used unnecessarily	0.76 (0.15,1.43)	1.01 (-1.29,1.58)	1.51 (0.76, 2.30)	1.01 (0.20,2.00)
AAI not used (correctly)	0.51 (-0.16,1.48)	0.20 (-0.83,1.13)	-0.77 (-1.96, 0.88)	0.09 (-0.85,1.03)
p Value	0.70	0.76	0.013	0.056
Overestimation of anaphylaxis risk				
AAI planned to be used unnecessarily	1.41 (0.78,2.33)	0.79 (-0.22,2.30)	-0.25 (-1.22, 1.06)	0.79 (-0.26, 2.01)
AAI not used (correctly)	0.78 (-0.89,1.75)	0.33 (-1.25,1.21)	0.75 (-0.74, 0.80)	0.75 (-0.75, 1.24)
p Value	0.16	0.11	0.82	0.093
Overestimation of fatal anaphylaxis risk				
AAI planned to be used unnecessarily	1.04 (-1.91,4.13)	1.58 (0.56,2.57)	1.05 (0.73, 2.33)	1.07 (0.80,2.08)
AAI not used (correctly)	1.20 (0.39,2.10)	0.42 (-0.35,1.80)	1.99 (-0.35, 2.63)	1.06 (0.40,2.10)
p Value	0.84	0.16	0.98	0.55

*AAI = Adrenaline Auto-Injector