

Epinephrine autoinjector availability among children with food allergy

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ABSTRACT

Epinephrine is the treatment of choice for anaphylaxis. Delay in administration of epinephrine is a known risk factor for food allergy reaction-related mortality; however, individuals with food allergy may not have epinephrine readily available. This study was designed to determine the percent of food-allergic children that have an epinephrine autoinjector readily available and factors associated with epinephrine autoinjector carriage rates. Parents completed a questionnaire on food allergy and food allergy preparedness. Staff recorded whether an epinephrine autoinjector and medical alert bracelet was immediately available in clinic. Parental responses from 63 food-allergic children were included. Fifty-nine percent (37/63) had an epinephrine autoinjector present in the clinic, and 79% (50/63) reported receiving training in epinephrine autoinjector use. There was no correlation between epinephrine autoinjector presence in the clinic and parental report of having an epinephrine autoinjector available at all times ($\phi = 0.21$). Epinephrine autoinjector training was associated with increased odds of having an epinephrine autoinjector immediately available (adjusted odds ratio, 8.74 [1.69, 45.04]). Fewer school aged children (≥ 5 years old) reportedly had their epinephrine autoinjector with them when eating lunch (25% [8/32] versus 42% [13/31]; $p = 0.002$) or snacks (28% [9/32] versus 37% [13/31]; $p = 0.005$) when compared with those < 5 years old. Many children do not have their epinephrine autoinjectors readily available despite parental report. Epinephrine autoinjector training improved the odds of having an epinephrine autoinjector readily available. Continued patient education on the importance of having an epinephrine autoinjector easily accessible, especially when eating, is important.

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Food allergy affects 6–8% of children ≤ 4 years of age and the prevalence has increased by 18% since 1997.^{1,2} Currently, avoiding known food allergens is the most advisable management strategy for food allergy; however, avoidance can not always be ensured. In a 5.4-year follow-up period, up to 55% of peanut-allergic patients had reactions due to accidental exposure.³ Timely administration of epinephrine decreases mortality from anaphylaxis. In fact, delay in administration of epinephrine (> 30 minutes) has been associated with increased risk of death due to anaphylaxis.^{4,5} Some individuals (17%) require a second dose of epinephrine.⁶ Typically, fatal food reactions occur within 30 minutes of exposure.⁴ In an evaluation of 6 such reactions in children, 66% occurred at school and only 1/6 (17%) received epinephrine within 30 minutes of a reaction.⁴ Despite this, many individuals with food allergy have never been prescribed an epinephrine autoinjector, have not been trained in its use, or do not carry it regularly.^{7–9}

According to the guidelines for the diagnosis and management of food allergy, epinephrine is the first-line treatment for anaphylaxis,¹⁰ but ensuring that food-allergic children receive the proper treatment in the event of food-related anaphylaxis is challenging. This is caused by multiple factors: food allergy is more common among young children; they are reliant on parents/caregivers to carry and administer the epinephrine autoinjector and may be in the care of multiple adults during the course of a day (daycare, school, etc.).

Multidisciplinary allergy clinics may have an impact on reducing subsequent food-related anaphylaxis rates and increasing the likelihood of having an epinephrine autoinjector regularly available.⁸ This study was aimed at identifying the percentage of children with food allergy having an epinephrine autoinjector on hand in our pediatric allergy clinic and factors associated with an epinephrine autoinjector being readily available.

METHODS

We conducted a cross-sectional study of 63 consecutive children presenting for evaluation at Emory Children's Center Allergy Clinic for food allergy. The primary outcome measure was percent of children having an epinephrine autoinjector immediately available as defined by a surrogate marker of having an epinephrine autoinjector in the clinic. Secondary aims included determining the percent of children with food allergy

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wearing a medical alert bracelet, identifying factors associated with having an epinephrine autoinjector in the clinic, correlating parental report that the epinephrine autoinjector is with them at all times with the presence of an epinephrine autoinjector in the clinic, determining percent of children with an epinephrine autoinjector available when eating lunch and snacks at school, and determining if age or grade was associated with availability of an epinephrine autoinjector during lunch and snacks.

Subjects

All children (birth to 18 years of age) presenting for evaluation at Emory Children's Center Allergy Clinic with a history of physician-diagnosed food allergy, evidence of food-specific IgE (positive skin-prick test or serum food-specific IgE), and who had previously been prescribed an epinephrine autoinjector for food allergy were eligible for inclusion. Exclusion criteria included no evidence of food allergy and children/parents unwilling to sign the consent form or participate. Each child completed one study visit and was included once.

Definitions

Food allergy was defined as physician-diagnosed food allergy and presence of food-specific IgE. All children had been provided an epinephrine autoinjector because of history of food allergy. Having an epinephrine autoinjector in the clinic was used as a surrogate measure that an epinephrine autoinjector is available at all times. History of epinephrine autoinjector training was defined as parental report of previous training in the use of an epinephrine autoinjector. History of life-threatening reaction to food was defined as parental report of a previous life-threatening reaction to a food, which was left to parental interpretation in an attempt to identify parent's perception of the severity of previous reactions.

Data Collection

Parents completed a questionnaire containing the following questions on:

1. Age, gender, and grade.
2. The child's food allergy including age at diagnosis, length of diagnosis, parental report of history of previous life-threatening reaction to food (yes/no), and parental perception that the food allergy is severe (yes/no).
3. Preparedness to treat a food allergy including questions about whether the epinephrine autoinjector is available at all times and whether they had previously been trained to use it.
4. School preparedness including whether the caregiver had discussed the child's food allergy with the

school, whether the school had a copy of a food allergy action plan, and whether the school staff had been trained to use the epinephrine autoinjector or read labels.

5. Whether the epinephrine autoinjector was available when eating lunch and snacks (yes/no).

As part of their visit, all children were seen by a pediatric allergist immunologist, the chart was reviewed, and caregivers were asked to show the epinephrine autoinjector and medical alert bracelet.

Statistical Analysis

Univariate analyses included *t*-tests for continuous variables, χ^2 -analysis for dichotomous variables, and Fischer's exact test for comparison of cells with $n < 5$. A logistic regression model (descending order) was used to identify factors associated with having an epinephrine autoinjector in the clinic at the time of visit. The dependent variable was staff determination that the epinephrine autoinjector was in the clinic (yes or no). Independent variables included age, gender, duration of food allergy, epinephrine autoinjector training, new patient/established patient, history of life-threatening reaction, and food allergy considered to be severe. The Φ -coefficient was used to determine the correlation between the epinephrine autoinjector being present in the clinic and parents' report that they keep with them at all times.

The cohort was divided into those ≥ 5 years of age (school age) and < 5 years of age. The χ^2 -analysis was used to determine differences in report that the child has an epinephrine autoinjector on hand when eating lunch and snacks between children < 5 years old and ≥ 5 years old. We separated those who were ≥ 5 years of age (school-aged children) by school grade and used χ^2 -analysis to determine differences in availability of the epinephrine autoinjector when eating lunch or snacks by grade. All data were analyzed using SAS Version 9.2 (SAS Institute Inc., Cary, NC).

Institutional Review Board Considerations

Emory University Institutional Review Board approved the project. All parents signed informed consent; consent was obtained (verbal, 6–11 years old, and written, 12–17 years old).

RESULTS

The parental responses to questionnaires on 63 food-allergic children were included with no refusals. Demographic data and baseline characteristics for the entire group and for the subgroups (< 5 years of age and ≥ 5 years of age) are shown in Table 1. Participants were 6.40 ± 4.14 years of age (male patients, 68% [43/63]; established patients, 83% [52/63]). They were 2.44 ± 2.65 years of age at diagnosis and had a diag-

Table 1 Demographic data and baseline characteristics of participants

Characteristic	Total Population*	Population < 5 yr#	Population > 5 yr#	p Value
<i>n</i>	63	31	32	
Age (yr)	6.40 ± 4.14	3.04 ± 1.02	9.66 ± 3.32	<0.0001
Gender, % male (<i>n</i>)	68 (43/63)	71 (22/31)	66 (21/32)	0.65
Percent established patients	83 (52/63)	74 (23/31)	91 (29/32)	0.08
Age at diagnosis of food allergy (yr)	2.44 ± 2.65	1.34 ± 0.92	3.55 ± 3.30	0.0007
Length of food allergy (yr)	4.18 ± 3.57	1.81 ± 1.09	6.54 ± 3.63	<0.0001
Percent reporting life-threatening reaction to food (<i>n</i>)	40 (25/63)	29 (9/31)	50 (16/32)	0.07
Percent reporting food allergies considered severe (<i>n</i>)	62 (39/63)	58 (18/31)	66 (21/32)	0.28
Percent trained in epinephrine autoinjector use (<i>n</i>)	79 (50/63)	74 (23/31)	84 (27/32)	0.29
Percent with epinephrine autoinjector with them during lunch (<i>n</i>)	33 (21/63)	42 (13/31)	25 (8/32)	0.002
Percent with epinephrine autoinjector with them during snacks (<i>n</i>)	35 (22/63)	42 (13/31)	28 (9/32)	0.005
Percent with epinephrine autoinjector in office (<i>n</i>)	59 (37/63)	52 (16/31)	66 (21/32)	0.26
Percent with medical alert bracelet in office (<i>n</i>)	6 (4/63)	10 (3/31)	3 (1/32)	0.29

*Data represent frequency percent or mean ± SD.

#Univariate analysis included t-test for continuous variables, χ^2 -analysis for dichotomous variables, and Fischer's exact test was used for comparison of cells with *n* < 5.

nosis of food allergy for 4.18 ± 3.57 years. Sixty-two percent (39/63) considered their child's food allergies to be severe, but only 40% (25/63) reported their child had previously had a life-threatening reaction after food ingestion.

School-aged children (*n* = 32) had a diagnosis of food allergy later (3.55 ± 3.30 years versus 1.34 ± 0.92 years; *p* = 0.0007) and longer (6.54 ± 3.63 years versus 1.81 ± 1.09 years; *p* < 0.0001) than children <5 years of age. Ninety-four percent (30/32) of caregivers reported discussing the food allergy with the school system, and 84% (27/32) reported providing the school with a food allergy action plan. Eighty-four percent (27/32) reported that the school staff was taught to read labels, and 72% (23/32) stated that the school staff was trained in epinephrine autoinjector administration technique.

Fifty-nine percent (37/63) were able to show the epinephrine autoinjector when asked, and 56% (35/63) of parents reported keeping the child's epinephrine autoinjector with them at all times. Seventy-one percent (25/35) reporting they keep the epinephrine autoinjector with them at all times actually had an epinephrine autoinjector in the clinic. There was no correlation between parental report that an epinephrine autoinjector is kept with them at all times and having the epinephrine autoinjector in the clinic ($\Phi = 0.21$).

Results of the univariate analysis of factors associated with having an epinephrine autoinjector in the clinic are shown in Table 2. A greater proportion of those with an epinephrine autoinjector in the clinic reported previous training in epinephrine autoinjector

use (89% [33/37] versus 65% [17/26]; *p* = 0.006). Epinephrine autoinjector training was the only variable associated with increased odds of having an epinephrine autoinjector in the clinic (crude odds ratio, 8.74 [2.0133, 52.9347]; *p* = 0.002). Results of the logistic regression analysis are shown in Table 3. The adjusted odds ratio for epinephrine autoinjector training was 8.74 (1.69, 45.04; *p* = 0.02).

Demographic data and baseline characteristics of the school-aged children (≥ 5 years old) are shown in Table 1. School age children (≥ 5 years old) were significantly less likely than children <5 years old to have an epinephrine autoinjector available during lunch (25% [8/32] versus 42% [13/31]; *p* = 0.002) and snacks (28% [9/32] versus 42% [13/31]; *p* = 0.005) (Fig. 1). The evaluation of epinephrine autoinjector availability when eating lunch and snacks by grade is shown in Tables 4 and 5. Children in elementary school (kindergarten–5th grade) and middle school (6th–8th grade) were less likely to have epinephrine autoinjectors available when eating lunch and snacks than children <5 years old. There was no difference in the availability of epinephrine autoinjectors when eating lunch and snacks between those in elementary school, middle school, or high school.

DISCUSSION

In this cross-sectional study, 41% of participants did not have an epinephrine autoinjector during a routine

Table 2 Univariate analysis of factors associated with epinephrine autoinjector presence in clinic

	Epinephrine Autoinjector Not in the Clinic*	Epinephrine Autoinjector in the Clinic*	p Value#
<i>n</i>	26	37	
Age	5.66 ± 3.38	6.92 ± 4.57	0.30
Gender, % male (<i>n</i>)	73 (19/26)	62 (23/37)	0.17
Percent established patients (<i>n</i>)	65 (17/26)	86 (32/37)	0.14
Age at diagnosis of food allergy (yr)	3.39 ± 2.72	4.74 ± 4.02	0.1476
Length of food allergy (yr)	3.39 ± 2.72	4.74 ± 4.02	0.1476
Percent reporting life-threatening reaction to food (<i>n</i>)	27 (7/26)	49 (18/37)	0.07
Percent reporting food allergies considered severe (<i>n</i>)	62 (16/26)	62 (23/37)	0.55
School age (≥5 years old) (yes or no)	38 (10/26)	54 (20/37)	0.35
Percent trained in epinephrine autoinjector use (<i>n</i>)	65 (17/26)	89 (33/37)	0.006

*Data represent frequency percent or mean ± SD unless otherwise indicated.

#Univariate analysis included *t*-test for continuous variables, χ^2 -analysis for dichotomous variables, and Fischer's exact test was used for comparison of cells with *n* < 5.

Table 3 Multivariate regression analysis for factors associated with epinephrine autoinjector presence in the clinic

Parameter	Estimate	χ^2	OR (95% confidence)	p Value
Age (yr)	-0.49	1.06	0.61 (0.24, 1.56)	0.30
Gender (female vs male)	1.23	2.20	3.42 (0.67, 17.37)	0.14
Established vs new patient	-0.56	0.41	0.57 (0.10, 3.22)	0.52
Age at diagnosis of food allergy (yr)	0.47	0.85	1.60 (0.59, 4.37)	0.36
Length of food allergy (yr)	0.52	1.22	1.67 (0.67, 4.26)	0.27
History of life-threatening reaction to food	0.93	1.26	2.52 (0.50, 12.73)	0.26
Parents consider food allergy to be severe	-0.11	0.02	0.89 (0.17, 4.62)	0.89
History of epinephrine autoinjector training	2.17	5.61	8.74 (1.45, 52.60)	0.02

OR = odds ratio.

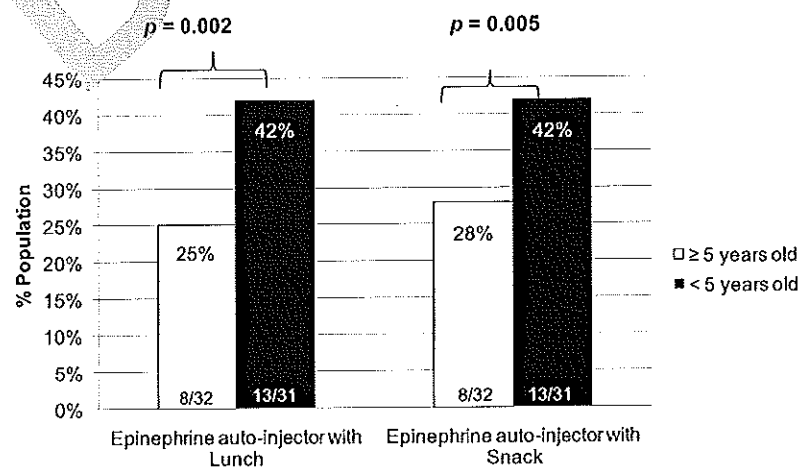


Figure 1. Shown is the prevalence of parental report of children (<5 years old and ≥5 years old) with an epinephrine autoinjector present when eating lunch or snacks.

Table 4 Participants reporting having epinephrine autoinjector available with eating lunch by grade

School	n	Percent with Epinephrine Autoinjector with Lunch (n)*	Comparison vs None#	Comparison vs Elementary#	Comparison vs Middle#	Comparison vs High#
None	31	42 (13/31)	—	$p = 0.006$	$p = 0.006$	$p = 0.40$
Elementary	20	25 (5/20)	$p = 0.006$	—	$p = 0.40$	$p = 0.36$
Middle	8	12.5 (1/8)	$p = 0.006$	$p = 0.40$	—	$p = 0.18$
High	4	50 (2/4)	$p = 0.40$	$p = 0.36$	$p = 0.18$	—

*Data represent frequency percent.

#Univariate analysis included χ^2 -analysis for dichotomous variables.

Table 5 Participants reporting having an epinephrine autoinjector available when eating snacks by grade

School	n	Percent with Epinephrine Autoinjector with Lunch (n)*	Comparison vs None#	Comparison vs Elementary#	Comparison vs Middle#	Comparison vs High#
None	31	42 (13/31)	—	$p = 0.01$	$p = 0.006$	$p = 0.40$
Elementary	20	30 (6/20)	$p = 0.01$	—	$p = 0.31$	$p = 0.49$
Middle	8	12.5 (1/8)	$p = 0.006$	$p = 0.31$	—	$p = 0.18$
High	4	50 (2/4)	$p = 0.40$	$p = 0.49$	$p = 0.18$	—

*Data represent frequency percent.

#Univariate analysis included χ^2 -analysis for dichotomous variables.

clinic visit. School age children (≥ 5 years of age) were more likely to consume lunch and snacks without availability of epinephrine autoinjectors. Epinephrine autoinjector training was the key variable associated with epinephrine autoinjector availability. However, despite intensive education in a subspecialty allergy setting, only 6% of children with food allergy wore a medical alert bracelet. These findings suggest that specialized educational interventions may be warranted in this population of children who are at high risk of food-related anaphylaxis.

The percentage of participants with epinephrine autoinjectors readily available in this study is consistent with other studies.^{7-9,11} In an evaluation of 120 children with food allergy, 69% reported that they always carried their epinephrine autoinjector.⁹ A similar study of 101 children with food allergy noted that 71% had epinephrine autoinjectors in the clinic, with 10% expired.¹¹ The factors responsible for our observations and those of others are unclear but may be related to a need for additional education of the importance of epinephrine autoinjectors.

The lack of availability of epinephrine autoinjectors at school during lunch and snacks is interesting. Overall, those who were ≥ 5 years of age were less likely than those who were < 5 years of age to have an epinephrine autoinjector available when eating

(lunch or snacks). On further investigation this finding was limited to elementary and middle school children. This may reflect a lack of understanding of the importance of epinephrine in the treatment of anaphylaxis on the part of school officials and/or school nurses, inappropriate school policies, or lack of school nurse supervision. Further investigation into factors related to availability of epinephrine autoinjectors at school is essential when considering that 66% of fatal food reactions occurred at school, and up to 50% of school children may experience a delay in anaphylaxis treatment because of reduced access to an epinephrine autoinjector.^{4,12} Our inability to find a difference between those in high school and elementary or middle school children may reflect differences in school policies, resources, or the small numbers of participants.

Epinephrine autoinjector technique training was the primary factor associated with epinephrine autoinjector availability in this study. Others have also indicated that training and specialist visitation is key to improving the availability of epinephrine autoinjectors and effective administration.^{7,13,14} In a study of 62 food-allergic children, those seen in a pediatric allergy clinic were more likely to carry an epinephrine autoinjector, show proper administration technique, and were more adept in managing allergic

reactions.⁸ Given the potential mortality associated with food allergy in children, these findings highlight the importance of subspecialist training and education. These data also emphasize the need for subspecialty referral of children with known or suspected food allergy by primary care providers.

Despite parental reports of having epinephrine autoinjectors available at all times, many parents did not have the epinephrine autoinjector available during the clinic visit. Furthermore, medical alert bracelets were rarely worn by affected children (6%). Thus, there appears to be an important disconnect between perception and behavior. We found no evidence that symptoms during previous food reactions affected the parents' decisions to carry an epinephrine autoinjector, because there was no association between having the epinephrine autoinjector in the clinic and parental report of previous life-threatening reaction to food or perception that the food allergy was severe.

With regard to medical alert bracelets, our findings are significantly lower than those previously reported (25%; 7/28).¹⁴ Although the reasons for this are unclear, it may be related to the relative young age of our sample (6.40 ± 4.14 years), in which 50% were <5 years of age. Medical alert bracelets may not properly fit the small wrists of young children and are easily lost. Alternatively, it may be that parents do not fully appreciate the susceptibility of their children to anaphylactic events or the severity of those events should they occur. More frequent and/or novel educational strategies may be needed to reinforce food allergy preparedness, including the importance of medical alert bracelets.

This study has a number of limitations, which include (1) use of epinephrine autoinjector in the clinic as our outcome measure (this may overestimate [if parents are more likely to have the epinephrine autoinjector during a clinic visit] or underestimate [if parents are more likely to believe it is unnecessary to have the epinephrine autoinjector because they are among medical providers] the true prevalence), (2) misclassification bias due to the definition of food allergy used (*i.e.*: not based on oral food challenges), (3) recall bias that may have affected answers to many of the questions on the questionnaire, (4) lack of questionnaire validation, and (4) small numbers of participants (especially in the subgroups). Although we found no evidence of association between parental perception of the severity of food allergies or previous history of life-threatening reactions to food, this study was not powered or designed to determine the effect of symptoms of previous food reactions on the probability of having an epinephrine autoinjector on hand. Despite these challenges we believe that our data are a valid "real-world" view of the availability of epinephrine autoinjectors among children with food allergy. Because our sample was recruited from a subspecialty allergy clinic,

the generalization of our findings to children in primary care clinics is also limited.

In summary, we have shown less than ideal epinephrine autoinjector availability for children with food allergy in the clinic, the school setting, and, presumably, in the home. These findings strengthen evidence for continued education reinforcing the need for epinephrine autoinjectors and medical alert bracelets. Quality-improvement initiatives to increase epinephrine autoinjector availability and ultimately decrease the rate of food allergy-related morbidity are needed.

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REFERENCES

1. Branum AM, and Lukacs S, and National Center for Health Statistics (U.S.). Food allergy among U.S. children: Trends in prevalence and hospitalizations. Hyattsville, MD: Department of Health and Human Services, Centers for Disease Control and Prevention, NCHS Databrief 2008; Oct(10):1-8.
2. Sampson HA. Food allergy. Part 1: Immunopathogenesis and clinical disorders. *J Allergy Clin Immunol* 103:717-728, 1999.
3. Sicherer SH, Burks AW, and Sampson HA. Clinical features of acute allergic reactions to peanut and tree nuts in children. *Pediatrics* 102:e6, 1998.
4. Sampson HA, Mendelson L, and Rosen JP. Fatal and near-fatal anaphylactic reactions to food in children and adolescents. *N Engl J Med* 327:380-384, 1992.
5. Pumphrey RS. Lessons for management of anaphylaxis from a study of fatal reactions. *Clin Exp Allergy* 30:1144-1150, 2000.
6. Banerji A, Rudders SA, Corel B, et al. Repeat epinephrine treatments for food-related allergic reactions that present to the emergency department. *Allergy Asthma Proc* 31:308-316, 2010.
7. Pouessel G, Deschildre A, Castelain C, et al. Parental knowledge and use of epinephrine autoinjector for children with food allergy. *Pediatr Allergy Immunol* 17:221-226, 2006.
8. Kapoor S, Roberts G, Bynoe Y, et al. Influence of a multidisciplinary paediatric allergy clinic on parental knowledge and rate of subsequent allergic reactions. *Allergy* 59:185-191, 2004.
9. Allen CW, Campbell DE, and Kemp AS. EpiPen use in children with food allergies. *Med J Aust* 187:542, 2007.
10. 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* 126:S1-S58, 2010.
11. Sicherer SH, Forman JA, and Noone SA. Use assessment of self-administered epinephrine among food-allergic children and pediatricians. *Pediatrics* 105:359-362, 2000.
12. Ben-Shoshan M, Kagan R, Primeau MN, et al. Availability of the epinephrine autoinjector at school in children with peanut allergy. *Ann Allergy Asthma Immunol* 100:570-575, 2008.
13. Arkwright PD, and Farragher AJ. Factors determining the ability of parents to effectively administer intramuscular adrenaline to food allergic children. *Pediatr Allergy Immunol* 17:227-229, 2006.
14. Hughes JL, and Stewart M. Self-administration of epinephrine in children: A survey of current prescription practice and recommendations for improvement. *Ulster Med J* 72:80-85, 2003. □