Obesity, low levels of physical activity and smoking present opportunities for primary care asthma interventions: an analysis of baseline data from The Asthma Tools Study

Barbara P Yawn1, Matthew A Rank2, Susan L Bertram3 and Peter C Wollan3

BACKGROUND: Asthma prevalence, severity and outcomes are associated with various patient characteristics and lifestyle choices. AIMS: To identify potentially modifiable factors associated with poor asthma outcomes among US primary care patients.

METHODS: Using baseline data from the Asthma Tools Study, we calculated cross-sectional frequencies of activity levels, smoking, secondhand smoke exposure and the presence of obesity, as well as rates of out-of-control asthma and asthma exacerbations. Frequencies were stratified by sex, and into three age groups: 5–11 years, 12–18 years and 19 years and older. Logistic regression was used to identify factors associated with each of the asthma outcomes.

RESULTS: In the 901 individuals enrolled in this asthma study, tobacco smoke exposure, obesity, low activity levels, poverty, inadequately controlled asthma and high asthma-related health-care utilisation were common. Across all age groups, obesity was associated with poorer asthma outcomes: either poor asthma control (odds ratio (OR) = 2.3, 95% confidence interval (CI) 1.1–4.7 in 5- to 11-year-olds and OR = 1.5, 95% CI 1.1–2.2 in adults) or asthma exacerbations (OR 2.9, 95% CI 1.6–5.1 in 12- to 18-year-olds and OR 1.7, 95% CI 1.1–2.5 in adults). Among adults, smoking was associated with both measures of poorer asthma outcomes; inadequate asthma control (OR = 2.3, 95% CI 1.5–3.5), and asthma exacerbations (OR 1.7, 95% CI 1.1–2.6), and low physical activity were associated with poor asthma control (OR = 1.5, 95% CI 1.1–2.2).

CONCLUSIONS: Obesity, low levels of physical activity and smoking are common, and they are associated with poor asthma outcomes in a sample of primary care patients, suggesting important targets for intervention.

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INTRODUCTION

Asthma is common among US children and adults, with up to 1 in 8–11 children and 1 in 13 adults having received a physician diagnosis of asthma.1,2 Asthma continues to be associated with a significant burden to patients, families and health-care systems.3–6 That burden has been shown to be increased in certain age, sex, race/ethnicity and family income groups.7–11 These commonly enumerated factors are seldom amenable to medical interventions. However, asthma prevalence, severity and outcomes are also associated with several potentially modifiable patient characteristics and lifestyle choices including level of obesity,12–14 smoking status,15 levels of physical activity16 and exposure to secondhand smoke.8,17–20 Primary care physicians and practices provide the majority of asthma care5 and are therefore appropriate sites in which to assess the frequency of the additional potentially modifiable characteristics and lifestyle choices, highlighting opportunities to use nonmedication-based interventions to improve asthma outcomes.

This study uses the baseline data from a large pragmatic trial (The Asthma Tools Study)21 designed to assess the impact of introducing an asthma management tool (the Asthma APGAR system) into primary care practices. Here we present information on baseline demographic and behavioural characteristics of the enrolled patients and compare those with asthma outcomes at and in the year before enrollment. The goal is to identify potentially modifiable behavioural characteristics that might improve asthma outcomes.

MATERIALS AND METHODS

The overall description of the Asthma Tools Study has been published previously.21 In summary, the Asthma Tools Study is a 5-year pragmatic trial comparing Asthma APGAR system–guided asthma management with usual care in family medicine and paediatric community practices. Patient enrollment occurred between February 2011 and February 2014, and baseline data for each patient were collected from the 12 months before enrollment. Therefore, the period covered by this sub-study analysis is February 2010 through February 2014. We collected the baseline data using two methods: a patient-completed survey given to the patient/parent on the date of enrollment, and medical record review of all the patients’ visits to the enrollment site for the 12 months before enrollment, not including the enrollment visit.

Patients and practices

Patients were enrolled from the 22 enrolled family medicine and paediatrics community practices. The practices were selected from primary care practices that were members of one or more practice-based research network, attempting to include sites from several regions of the US (SouthEast, NorthEast, MidWest, SouthWest and West Coast) and from rural areas, small- to medium-sized cities and large urban areas. (See designation on the map, Figure 1.) Patients were identified as having

1Department of Research, Olmsted Medical Center, Rochester, MN, USA; 2Division of Allergy, Asthma and Clinical Immunology, Mayo Clinic, Scottsdale, AZ, USA and 3Department of Research, Olmsted Medical Center, Rochester, MN, USA.

Correspondence: BP Yawn (byawn@olmmed.org)

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persistent asthma and identified by an asthma ICD-9 diagnostic code plus a current prescription for one or more daily maintenance medications from the practice’s electronic health record or as patients meeting these characteristics visited the practice for asthma-related concerns. Of the patients offered enrollment, over 90% accepted.

Data collection

The baseline enrollment survey collected extensive patient/parent-reported information on the following: patient’s personal characteristics; asthma-related information—sources of asthma care; number of visits to the emergency department hospital; or receipt of oral or intramuscular steroids for asthma in the previous 6 months, as well as difficulty obtaining asthma care in the previous year. A measure of the enrolled patients’ level of current asthma control was collected using the Asthma APGAR.22,23 The Asthma APGAR asks three questions about the frequency of activities that were missed or modified because of breathing problems, the frequency of daytime asthma symptoms and the frequency of night-time asthma symptoms over the previous weeks. An Asthma APGAR score of >2 is comparable to an Asthma Control Test score of <20.15,24 In addition to a ‘control score’, the Asthma APGAR asks questions about asthma triggers, use and adherence to asthma medications and the patient’s assessment of the impact of their asthma medications. The responses are linked to a care algorithm recommending next steps of care. For the baseline period, the practices did not have access to the Asthma APGAR. (Asthma APGAR is displayed in the Supplementary Figure.)

The patient’s age, sex, race/ethnicity, level of obesity, smoking status, estimated weekly activity levels, exposure to secondhand smoke and household income were all patient reported. Obesity was assessed on the basis of the patient’s body mass index (BMI, height and weight) measured and documented in the patient’s medical record during a visit in the baseline year. We required that both height and weight be measured (not patient estimate or report) at the same visit in children and adolescents and within the baseline year for adults, as adults are unlikely to gain weight. The BMI for children aged 5 through 18 years is reported as the percentile on standard age-specific growth curves and summarised as underweight (<5%), normal weight (5 to 85%), overweight (>85 to 95%) and obese (>95%).25,26 For adults, we used the US Center for Disease Control and Prevention (CDC) recommended cut-offs for underweight (BMI < 18.5), normal weight (BMI 18.5–24.9), overweight (25.0–29.9), obese (30.0–35.0) and morbidly obese (BMI > 35.0).27,28

The self-reported data were collected using previously developed or validated questions whenever possible. Smoking status, race/ethnicity and household income were collected using questions from the Behavioral Risk Factor Survey,29 the National Health Interview Survey30 or Medical Expenditure Panel Survey.31 When we found no standardised or validated question, we developed questions specifically for this study. Activity frequency was asked on a daily basis, which allowed collapse into longer periods. The levels of activity queried (moderate or strenuous) were adapted from the 2000 International Physical Activity Questionnaire,32 and results were compared with the 2010 CDC recommendations for physical activity.33,34 The questions on secondhand smoke exposure were designed to address the sights where children, adolescents and adults spend significant portions of time that are not regulated by indoor smoking laws: e.g., home and cars. The questions included in the baseline survey are in Supplementary Table 1.

We chose to present results within age groupings similar to those used in the US national asthma guidelines—e.g., 5 through 11 years, 12 through 18 years and 19 years and older, and labelled the groups as children, tweens and adults, respectively.35

The asthma control outcome is based on the patient/parent’s completed Asthma APGAR score, with a score of >2 considered to be inadequate control.22,23 To compare patient-perceived asthma control with that from a validated objective metric, we used the final question from the Asthma Control Test, which asks patients to report their perceived level of asthma control.24

Overall, 1,176 patients were enrolled in the Asthma Tools study between 2011 and 2014. Of the enrolled patients, 901 (77%) returned a useable baseline survey; e.g., responses were completed to over 90% of survey items. The rates of return varied among the enrolled patients from 76% in children to 73% in tweens and 67% in men to 83% in women (P = 0.03). Across all age groups, male patients were less likely than female patients to return the survey, although the differences were only significant for the adults. Among the adults, younger individuals (P < 0.0001) and those with higher BMIs (P < 0.05) were also less likely to return baseline surveys.

Data analysis

Patient characteristics were tabulated, and percentages were computed based on the individuals responding to the item. Characteristics were compared using Wilcoxon rank-sum tests for numeric data and Chi-squared tests for frequencies. Logistic regression was used to identify characteristics associated with asthma control, as determined by Asthma APGAR >2 and for asthma exacerbations determined by self-reported emergency department (ED) or hospital visits or steroid bursts for asthma. For multivariable modelling, a step-down procedure was used, starting with all variables and removing those with the highest P values first. All analyses were completed in S-Plus v. 7.0.6 (Tibco, Boston, MA, USA).

RESULTS

Demographics of the primary care asthma sample

Table 1 summarises the demographic information for the 901 primary care patients included in this sub-study. Enrollment rates by sex reflect the known higher prevalence of asthma in boys, reversing to more women than men in adulthood. The population is racially and ethnically diverse with 20% or more Hispanic individuals in each age group but decreasing numbers of
Table 1. Demographic and self-reported behaviors

| Characteristics by age group | Enrolled and returned baseline survey N = 893 |
|-----------------------------|-----------------------------------------------|
|                             | All   | Boys | Girls |
| N = 216                    | N = 137 | N = 79 |
| Age in years: mean 8.4 8.5 8.3 | %  %  % |
| Family income per year < $10,000 | 15.9 | 17.0 | 13.9 |
| $10,000 to $24,999 | 21.0 | 20.7 | 21.5 |
| $25,000 to $49,999 | 20.1 | 17.1 | 25.3 |
| ≥ $50,000 | 39.7 | 40.8 | 38.0 |
| Not reported | 3.3 | 4.4 | 1.3 |
| BMI | % Obese | 21.4 | 16.9 | 29.0 |
| % Overweight | 14.0 | 14.6 | 13.1 |
| % Healthy | 56.5 | 59.6 | 51.4 |
| % Underweight | 3.5 | 5.1 | 0.9 |
| % Not available | 4.6 | 3.9 | 5.6 |
| Smoking | % Doing moderate activity 3 Times a week, 15 min | 39.8 | 40.2 | 38.8 |
| > 3 Times a week, 15 min | 39.4 | 39.4 | 39.2 |
| > 5 Times a week, 15 min | 58.3 | 52.0 | 62.0 |
| > 5 Times a week, 15 min | 29.6 | 36.5 | 17.7 |
| Family income/year | % Not available | 9.0 | 15.6 | 6.9 |
| Parent-reported use of influenza vaccine % always or usually | 3.9 | 3.5 | 4.2 |
| Allergy testing ever, % yes | 43.3 | 45.9 | 38.0 |
| Needed asthma care and could not get it | 6.1 | 7.5 | 3.9 |
| Tweens (12–18 years) | All | Boys | Girls |
| N = 153 | N = 83 | N = 70 |
| Age in years: mean 15.2 14.7 15.8 |
| Race/ethnicity | White | 78.4 | 75.6 | 82.1 |
| Black | 14.4 | 20.0 | 11.9 |
| Native American | 1.3 | 2.3 | 0 |
| Other/none | 2.6 | 3.5 | 1.5 |
| Hispanic | 3.7 | 2.3 | 4.5 |
| Family income per year | % Obesity | 27.5 | 28.3 | 26.5 |
| % Overweight | 19.0 | 14.2 | 24.5 |
| % Healthy | 43.1 | 46.0 | 39.8 |
| % Underweight | 3.8 | 6.2 | 1.0 |
| % Not available in 1 year | 6.6 | 5.3 | 8.2 |
| Smoking | Primary | 1.3 | 1.3 | 1.5 |
| Secondhand smoke (any) | 54.1 | 49.4 | 59.7 |

Table 1. (Continued)

| Tweens (12–18 years) | All | Boys | Girls |
| N = 153 | N = 83 | N = 70 |
| 5–7 Days per week ever | 24.8 | 24.4 | 25.4 |
| 5–7 Days per week now | 17.0 | 18.6 | 14.9 |
| Activity level | % Doing moderate activity | 3 Times a week, 15 min | 58.2 | 55.8 | 61.2 |
| > 3 Times a week, 15 min | 30.7 | 30.2 | 31.3 |
| Doing strenuous activity | > 3 Times a week, 15 min | 51.0 | 53.5 | 47.8 |
| > 5 Times a week, 15 min | 28.1 | 30.2 | 25.4 |
| Self-reported use of influenza vaccine | % always or usually | Yes | 44.7 | 44.2 | 44.8 |
| Allergy testing ever, % yes | 6.8 | 6.3 | 7.6 |
| Activity level | % Needed asthma care and could not get it | 6.8 | 6.3 | 7.6 |

Table 1. (Continued)

| Adults >18 years | All | Boys | Girls |
| N = 533 | N = 128 | N = 405 |
| Age in years: mean 40.6 | 39.8 | 40.9 |
| Race/ethnicity | White | 89.3 | 91.4 | 88.6 |
| Black | 7.9 | 3.9 | 8.4 |
| Native American | 1.0 | 2.3 | 1.0 |
| Asian | 1.0 | 1.0 | 1.0 |
| Other/none | 1.0 | 0.8 | 1.0 |
| Hispanic | 3.9 | 3.5 | 4.2 |
| Family income/year | % Morbidly obese | 16.8 | 8.6 | 19.4 |
| < $10,000 | % Obese | 33.6 | 32.0 | 34.1 |
| $10,000 to $24,999 | % Overweight | 25.2 | 34.4 | 22.4 |
| > $25,000 to $49,999 | % Normal weight | 15.0 | 7.8 | 17.2 |
| ≥ $50,000 | % Underweight | 0.4 | 1.6 | 0.0 |
| BMI (mean and range) | % Not reported | 9.0 | 15.6 | 6.9 |
| N (12–11) | N (12–52) | N (19–71) |
| < $10,000 | 16.5 | 10.9 | 18.3 |
| $10,000 to $24,999 | 16.5 | 10.9 | 18.3 |
| > $25,000 to $49,999 | 19.2 | 20.3 | 18.7 |
| ≥ $50,000 | 45.9 | 56.3 | 42.7 |
| Smoking | % Not reported | 9.0 | 15.6 | 6.9 |
| Primary | 15.4 | 13.3 | 16.0 |
| Secondhand smoke (any) | 60.7 | 60.3 | 60.8 |
| 5–7 Days per week ever | 64.2 | 62.5 | 64.7 |
| 5–7 Days per week now | 22.5 | 18.8 | 23.7 |
| Activity level | % Doing moderate activity | 3 Times a week, 15 min | 39.8 | 43.0 | 38.8 |
| > 3 Times a week, 15 min | 18.5 | 23.4 | 17.5 |
| Doing strenuous activity | > 3 Times a week, 15 min | 24.0 | 37.5 | 19.8 |
| > 5 Times a week, 15 min | 9.0 | 15.6 | 6.9 |
| Self-reported use of influenza vaccine | % always or usually | Yes | 58.5 | 57.0 | 59.0 |
| Allergy testing ever, % yes | 57.2 | 63.3 | 54.6 |
| Needed asthma care and could not get it | 20.8 | 15.7 | 21.9 |

*Those with statistical difference in row frequencies (P < 0.05).
had BMIs at or above the 85 percentile of weight for all similarly aged children or tweens of the same sex. Overall, 46% of the adults had a BMI of 25 or greater. Exposure to tobacco smoke was common among all enrollees, with more than 1 in 8 adults reporting themselves as smokers with daily secondhand smoke exposure in 1 in 8 children, 1 in 6 tweens and 1 in 4 adults.

Self- or parent-reported activity decreased with age. Although 30% of children and 28% of tweens met or exceeded the CDC’s recommendation for levels of weekly activity of 15 or more minutes of moderate activity 5 or more days a week, only 9% of adults met the recommended 15 or more minutes of moderate activity 5 or more days per week.30,34 Girls and women were less likely than boys or men to do at least 15 or more minutes of strenuous activity 5 or more days per week.

Self-reported unmet need for asthma care. These characteristics were associated with out-of-control asthma, and the factors associated with out-of-control asthma, and the factors associated with out-of-control asthma. In multivariable modelling. For adults 19 years and older, Black race, annual family income of $50,000 was significantly associated with asthma exacerbations. Race, obesity and smoking remained significant in multivariable logistic regression in adults (Table 4).

**DISCUSSION**

Main findings

This group of children, tweens and adults have multiple adverse health and asthma risk factors. They are commonly exposed to tobacco smoke, often overweight, have modest levels of physical activity, limited family incomes, significant asthma-related health-care utilisation of urgent, emergent and hospital care, high rates of out-of-control asthma and a significant self-reported unmet need for asthma care. These characteristics suggest multiple opportunities for intervention and highlight potential barriers that family physicians and paediatricians face in providing asthma care to their patients.
Interpretation of findings in relation to previously published work. Among our group of patients, smoking was significantly associated with both out-of-control asthma and asthma exacerbations among the adults. This provides further support for the need to address smoking at each visit, as repeated attempts for smoking cessation supported by combination therapy can reduce smoking rates significantly. The self-reported rates of tobacco use among these adults are similar to the overall US population for adults. Non-obese was the reference group. The definition for obesity was appropriate to the age group considered and varied for those <19 and adults. Non-obese was the reference group. Activity was self-reported; current smoking status and non-smoking was the reference group. Smoking was self-reported; current smoking status and non-smoking was the reference group.

Although secondhand smoke exposure did not rise to the level of statistical significance in relation to poor asthma outcomes, tobacco smoke is a well-recognised trigger for asthma symptoms and exacerbations. Exposure to any secondhand smoke was common among these patients, with more than 1 in 3 children and tweens with asthma were 1.2 times more likely to be overweight (>95% of expected weight for age). The problem was even more pronounced in adults in whom obesity and morbid obesity rates were 1.5 times that of the US adult population. Other studies have also linked obesity with adverse asthma outcomes, including poorer control and increased weight management programmes requiring intensive long-term intervention. Among this group of people with asthma, activity levels were at least moderate activity five or more times per week or 15 or more minutes of strenuous activity two or more times per week.

### Table 3. Factors associated with out-of-control asthma

| By age group | Factor       | Odds ratio (CI 95%) | P-value |
|--------------|--------------|---------------------|---------|
| 5–11 Years   | Obesity      | 2.3 (1.1–4.7)       | 0.03    |
|              | Family income| 1.5 (1.1,2.0)       | 0.007   |
| Multivariable| Family income| 1.5 (1.1,2.0)       | 0.007   |
| 12–18 Years  | No factors are significant |            |         |
| 19+ Years    | Smoking      | 2.3 (1.5,3.5)       | <0.001  |
|              | Family income| 2.1 (1.5,3.0)       | <0.001  |
|              | Race (Blacks)| 2.2 (1.03,4.8)      | 0.02    |
|              | Morbid obesity| 1.5 (1,1.22)       | 0.008   |
|              | Less activity| 1.5 (1.1, 2.2)      | 0.01    |
|              | Gender (female)| 1.6 (1,04,23)     | 0.02    |
| Multivariable| Smoking      | 1.7 (1,1.27)        | 0.01    |
|              | Morbid obesity| 1.7 (1,1.30)       | 0.02    |
|              | Family income| 1.6 (1,1.24)        | 0.01    |

Variables considered are as follows: age, gender, race, income, activity, flu vaccination, smoke exposure and obesity. Variables were fit singly (univariate modelling), and then a stepwise procedure examined all the variables together.

### Table 4. Factors associated with ≥1 asthma exacerbations in previous 6 months

| By age group | Factor       | Odds ratio (CI 95%) | P-value |
|--------------|--------------|---------------------|---------|
| 5–11 Years   | Family income| 1.5 (1,1,2,0)       | 0.01    |
| Multivariable| Family income| 1.5 (1,1,2,0)       | 0.01    |
| 12–18 Years  | Obesity      | 2.9 (1,6,5,1)       | <0.0001 |
|              | Race         | 0.3 (0,1,0,9)       | 0.03    |
| Multivariable| Obesity      | 3.0 (17,5,3)        | <0.0001 |
|              | Race (Black) | 0.3 (0,1,0,9)       | 0.03    |
| 19+ Years    | Smoking      | 1.3 (1,04,1,6)      | <0.0001 |
|              | Family income| 1.4 (1,1,1,7)       | 0.003   |
|              | Race (Blacks)| 2.4 (1,2,4,7)       | 0.01    |
| Multivariable| Smoking      | 1.3 (1,04,1,6)      | 0.02    |
|              | Morbid obesity| 1.7 (1,1,2,6)     | 0.02    |
|              | Race (Black) | 4.0 (2,0,8,0)       | <0.001  |

Variables considered are as follows: age, gender, race, income, activity, flu vaccination, smoke exposure and obesity. Variables were fit singly (univariate modelling), and then a stepwise procedure examined all the variables together.

### References

17-19 Every asthma visit represents an intervention opportunity. At every age, being overweight or obese was associated with adverse asthma outcomes: having out-of-control asthma in children and adults, and experiencing asthma exacerbations in tweens and adults. Compared with the US obesity rates reported from the CDC’s National Health and Nutrition Examination Survey, these children and tweens with asthma were 1.2–1.3 times more likely to be obese (>95% of expected weight for age). The problem was even more pronounced in adults in whom obesity and morbid obesity rates were 1.5 times that of the US adult population. Other studies have also linked obesity with adverse asthma outcomes, including poorer control and increased asthma severity. Our data highlight an important opportunity for family physicians and paediatricians to discuss the impact of weight, eating and activity choices on adverse asthma outcomes, including poorer control and increased asthma severity.42 Our data highlight an important opportunity for family physicians and paediatricians to discuss the impact of weight, eating and activity choices on adverse asthma outcomes, including poorer control and increased asthma severity.42

Among this group of people with asthma, activity levels were reported to be moderate to low and to decrease to very low levels in tween girls and women. Up to 20% of the children and tweens and over 33% of women reported no days of even 15 min of activity in a week. Current US CDC recommendations for the general health of children, adolescents and adults include at least 60 min of moderate or more strenuous aerobic activity each day with added muscle strengthening and bone strengthening pursuits.33,44 Primary care physicians and other clinicians have
an opportunity to discuss the impact of activity on asthma and weight management.16

Patients’ willingness to engage in discussions related to changing behaviours may be based on their perceptions of health (e.g., asthma control) and personal goals.45 As has been reported previously,46 this group of parents and patients also appeared to overestimate their asthma control. This may represent a personal preference related to the perceived burden versus benefit of behaviours or lifestyle choices that could improve asthma control. Conversely, it may represent a misunderstanding of what has to be accepted as ‘normal’ for a person with asthma. Awareness of the gap between patient/parent and health professionals’ assessments of asthma status may represent another important opportunity for addressing both medication use and lifestyle changes to address factors adversely affecting asthma including obesity, smoking and activity.

Strengths and limitations of this study
The strengths of this study include the large sample size, the inclusion of patients from a wide diversity of regions of the United States, and multiple practices. We collected data on several health-related conditions that are seldom addressed in pragmatic asthma trials including secondhand smoke exposure, activity, obesity and race. Our study also has several limitations including responder bias. As reported previously,7 the responders to the initial survey differed from the nonresponders in some characteristics that we could identify from the medical record reviews, including age, gender and BMI, with the nonresponders more likely to be men, younger and to have a BMI in the overweight or obese range. It is not clear how age and gender might affect the factors we found to be associated with poorer asthma outcomes. However, it is possible that the increased responder rate for obese individuals may have resulted in an underestimation of the impact of obesity on the outcomes of interest. Some of the factors reported are not modifiable in the usual health-care setting but could be used to alert health-care professionals to the increased likelihood of poor asthma outcomes and to search for modifiable factors such as inability to buy healthier foods, avoid smoke exposure or the lack of a safe place to do physical activities.

Implications for future research, policy and practice
Future studies that address pragmatic approaches to improved asthma outcomes need to go beyond medication-based asthma management to address other modifiable factors and lifestyle choices. Specifically, prospective studies to further establish causality between lifestyle choices and asthma outcomes are required, as are clinical trials to demonstrate the ability of interventions to increase exercise and reduce weight and smoke exposure to improve asthma control. Primary care is the appropriate site to encompass approaches to most of the patient’s health-care needs, and these data stress the continuing need to address obesity, activity, secondhand smoke exposure and smoking in asthma management.

Conclusions
Among this sample of primary care patients with asthma, inadequate asthma control and risk of exacerbation were associated with factors for which interventions are possible: smoking, exposure to secondhand smoke, low levels of physical activity and obesity. These findings suggest that primary care health professionals consider these potentially modifiable elements of asthma management during each visit.

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CONTRIBUTIONS
All authors contributed to the work and were involved in the study design, data collection, statistical analysis and writing of the manuscript. Dr Barbara Yawn is the corresponding author.

COMPETING INTERESTS
The authors declare no conflict of interest.

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