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A natural experiment on the impact of fruit supplementation on asthma symptoms in children

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ABSTRACT: A high fruit intake may reduce the risk of asthma.

The English National School Fruit Scheme was introduced in the East Midlands region of the UK in June 2003 and in the Eastern region in September 2004. Questionnaires were distributed to children aged 4–6 yrs in schools in May 2003. This was repeated in May 2004 when those in the East Midlands had received free fruit for 1 yr and those in the Eastern region had not.

Responses were obtained in 2004 for 4,971 (53%) and 5,770 (54%) children in the intervention and control regions, respectively. Despite an increase in fruit consumption in the intervention compared with the control region between 2003 and 2004, there was no difference between the two regions in the prevalence or severity of asthma symptoms after 1 yr of fruit supplementation (odds ratio for wheeze in the past 12 months in intervention compared with control region 1.00, 95% confidence interval 0.88–1.14).

Providing free fruit at school for 1 yr does not have any immediate effect on prevalence or severity of asthma in young children, although these data do not refute the hypothesis that a higher increase in fruit intake improves measures of asthma control.

KEYWORDS: Asthma, children, diet, fruit

It has been hypothesised that a reduced consumption of dietary antioxidants may have contributed to the increase in asthma prevalence seen in developed countries over recent decades [1]. Fruit is one of the main dietary sources of antioxidants [2], and a higher intake of fruit has been associated with a lower prevalence of asthma symptoms in many [3–12] but not all published studies of this relationship [13–18]. In children aged 6–7 yrs, those who ate fruit on at least 5 days per week were reported to have >60% reduction in the risk of shortness of breath with wheeze compared with those who never ate fruit [5]. However, patterns of antioxidant intake are strongly linked to socio-economic status [2], which may therefore have confounded the observed associations. It is important to clarify the relationship between low fruit intake and asthma, since, if causal, this may permit affordable interventions to both prevent and treat this common childhood disease. Controlled intervention studies are needed to demonstrate the true size of the effect of dietary fruit intake on asthma, but are these are scarce, probably because they are difficult to design and invariably expensive.

The National School Fruit Scheme (NSFS) is a UK government initiative designed to increase fruit intake in children by providing each child aged 4–7 yrs in England with a free piece of fruit each day in school. As this programme was implemented in a phased manner on a region by region basis, the current authors took the opportunity to evaluate the impact of this public health dietary intervention for 1 yr on the prevalence and severity of asthma symptoms in children who received fruit in the scheme in one region of the country, compared with children in another region who did not receive fruit.

METHODS

Study population

In May 2003, a random sample of 113 schools in the East Midlands and 122 schools in the Eastern region of England was recruited, and baseline data on diet and respiratory symptoms were collected using a short parentally completed questionnaire from all children who were then in Reception or Year 1 (aged 4–6 yrs) in these schools, as described previously [14]. As part of the phased implementation of the NSFS, children of these ages in the East Midlands region

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received daily fruit (generally including apples, oranges or pears) in school from June 2003, while those in the Eastern region received similar daily fruit from September 2004 (fig. 1). All of the schools that participated in 2003 were invited to redistribute the same questionnaire in May 2004 to all children in Years 1 or 2 (then aged 5–7 yrs), by which time children in the East Midlands region had received daily fruit for ~1 yr, while those living in the Eastern region (which acted as a control group) had not. Ethics approval was obtained from the Eastern Multiple Regional Ethics Committee.

Measurements

Fruit intake was quantified by asking how many days in a typical week the child ate fruit either at school or at home, excluding fruit juice, and how many pieces of fruit were consumed on average each day. No data were collected on other dietary choices or vitamin supplementation. A continuous measure of the number of pieces of fruit per week was derived by multiplying the number of days on which fruit was eaten per week by the number of pieces of fruit eaten each day. Details of the occurrence of wheeze, exercise-induced wheeze and nocturnal cough were obtained using questions based on standard International Study of Asthma and Allergies in Childhood phrasing [19]. The current authors also asked about asthma diagnosed by a doctor, and whether the child had a bronchodilator or steroid inhaler for asthma and, if so, how many inhaled doses they had used in the past week. The completed questionnaires were scanned and entered into a database (Document Capture Co., Wembley, UK), and responses from 2003 and 2004 were linked. Parents provided their postcode, which was linked using the postcode-enumeration district directory in the Manchester Information and Associated Services to census enumeration district, and in turn to the Townsend Z-score for the 1991 census, as a marker of socio-economic status (a normally distributed measure, with negative scores indicating higher and positive scores lower socio-economic status).

Data analysis and statistical methods

The prevalence of wheezing in the past 12 months and exercise-induced wheezing and nocturnal cough in the past 12 months were compared, as two alternative indicators of current asthma, between children living in the East Midlands (intervention) and Eastern (control) regions, using the cross-sectional data in 2004, and using the paired data for those with responses in 2003 and 2004 to adjust for baseline differences between the two areas. In subgroups of children with asthma in 2003, defined by either current wheezing, use of a bronchodilator or use of a steroid, the occurrence of wheeze in the past 12 months, bronchodilator use and use of a steroid inhaler (markers of persistence of asthma symptoms) were compared between the two regions in 2004. Clustering at school level was allowed for in all analyses. Initially, binary outcomes between intervention and control schools were compared by calculating the individual school proportions and comparing the means or medians of the cluster proportions by independent t-test or Mann–Whitney U-test as appropriate to their distribution. Multi-level modelling in MLWin (Institute of Education, London, UK) and a logistic regression model with a random intercept for school were then used, to determine the odds ratio (OR) and the 95% confidence interval (CI) for the effect of intervention compared with control on the asthma-related outcomes, and also to adjust for 2003 baseline differences between intervention and control areas. Significance was defined as $p<0.05$.

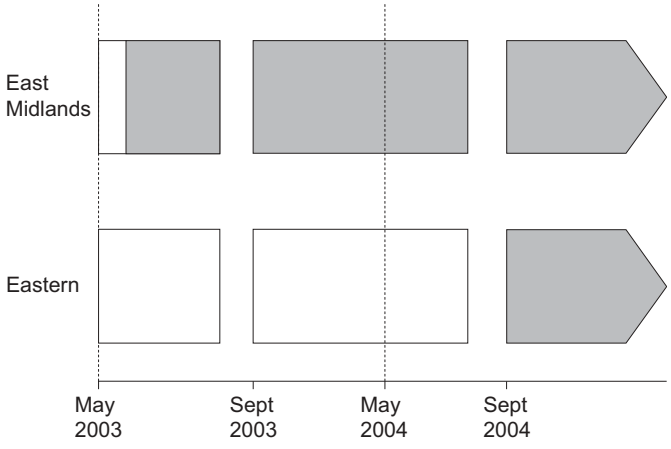

FIGURE 1. A summary of the phased implementation of the National School Fruit Scheme for participating schools. ■: participation in the scheme. ·····: diet and asthma questionnaires given.

Assuming a mean prevalence of wheeze in the past 12 months of 15% and a standard deviation of 5% for the distribution of wheeze between schools (data taken from a previous study of primary schools in Nottinghamshire, UK [20]), it was calculated that 100 schools were required in each group to detect a difference of 2% prevalence of wheeze between the schools that received fruit supplementation at the end of the study and those that did not, with 90% power and 5% significance.

RESULTS

Survey respondents' demographics and fruit consumption

The recruitment for the study is summarised in figure 2. The response rates for children from intervention and control schools were 56% and 52%, respectively, in 2003, and 53% and 54% in 2004. It was possible to link data from 2003 and 2004 for 3,233 and 3,506 children, respectively, representing 58% of all those who responded in 2003. At baseline in 2003, children in intervention and control schools were comparable in distribution of sex and age (table 1). Fruit intake for all respondents at baseline in 2003 was significantly lower in the intervention compared with the control schools; the estimated median numbers of pieces of fruit per child per week were 8.0 and 10.7, for intervention and control schools respectively. For those who responded in both the 2003 and 2004 surveys, the median baseline fruit intakes were 9.0 and 11.0 pieces of fruit per child per week, for intervention and control schools respectively. In 2004, after the NSFS had been implemented in the intervention region for ~1 yr, the weekly median number of pieces of fruit eaten by each child in the intervention region was 14.0, while the comparable quantity for the control region was 12.0 pieces per child per week. The Townsend Index was also higher at baseline for children in the intervention schools than the control schools, reflecting greater social disadvantage (median values -1.2 and -1.4, respectively). Those who participated in both the 2003 and 2004 surveys were similar in distribution of

sex and age to those who responded in 2003 (table 1), but were slightly less likely to wheeze.

Asthma symptoms in intervention and control populations

In 2003, there was no difference in the baseline prevalence of wheeze in the past 12 months at baseline between children in the intervention and control regions (table 1). In 2004, after the children in the intervention region had received fruit at school for ~1 yr, there was still no difference in the 12-month period prevalence of wheezing between intervention and control schools; the mean proportions across schools in the intervention and control regions were 11.9 and 12.0%, respectively (OR 1.00, 95% CI 0.88–1.14). There was also no difference in 2004 in the prevalence of exercise-induced wheeze (mean proportions 7.9 and 7.5%, respectively; OR 1.05, 95% CI 0.88–1.26) or nocturnal cough (20.6 and 18.8%, respectively; OR 1.09, 95% CI 0.96–1.24). Adjusting for age, sex, Townsend Score, exposure to smoking at home or baseline wheeze prevalence did not alter these results. A *post hoc* cross-sectional analysis of the 2003 and 2004 data sets demonstrated no association between fruit intake in categories and risk of parentally reported wheeze in the past 12 months in either cross-sectional data set (Chi-squared tests for trend: $p=0.22$ and $p=0.40$, respectively).

Asthma symptoms in intervention and control populations in those with asthma symptoms in 2003

In children who reported current wheeze in 2003, there was no difference in the proportion continuing to wheeze in 2004 (median 67% for intervention and 67% for control schools; $p=0.8$) or in the frequency of attacks; the median number of asthma attacks in the past year per child was two, for both the intervention and control schools. In children who had recently used a bronchodilator in 2003, the median proportion of children continuing to use it (at least once in the last week) in 2004 was 67% for intervention and 50% for control schools ($p=0.6$). Most children who were using a steroid in 2003 continued to do so in both intervention and control regions, with a median proportion of 100% doing so in both regions.

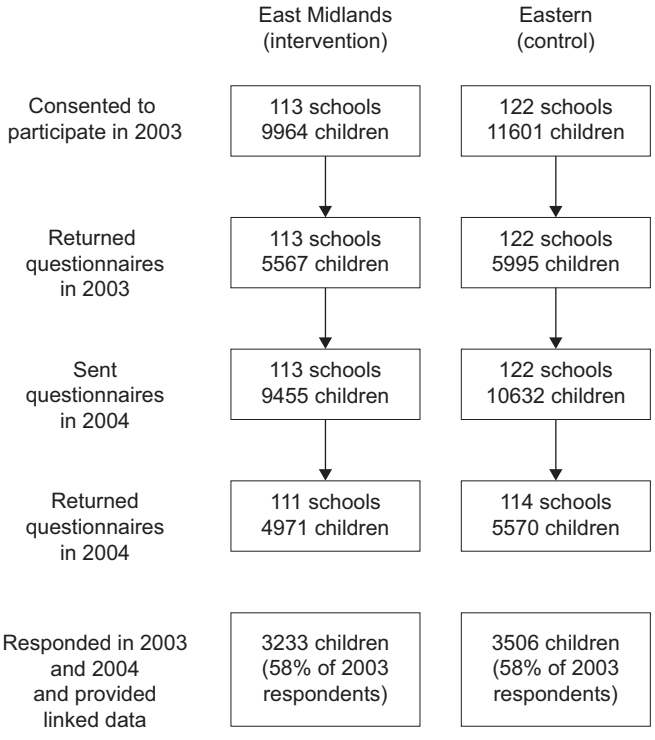

FIGURE 2. The response rates for schools and individuals for the 2003 and 2004 surveys.

DISCUSSION

Many cross-sectional studies have reported that a high fruit intake is associated with a lower risk of asthma symptoms [3–12], and the need for intervention studies using fruit for asthma symptoms has been highlighted [21]. The present study is the first to look opportunistically at the effect on asthma symptoms of a population-based intervention aiming to increase fruit intake in young children. The findings demonstrate that, despite a 20–25% increase in weekly fruit intake, fruit supplementation at school had no effect on any of the measures of asthma prevalence or severity in children aged 5–7 yrs.

The present study used a prospective design, comparing prevalence of asthma-related symptoms and change in measures of parentally reported asthma before and after the implementation of the NSFS in one region with those in a second region that acted as a control. The response rate in each region at each time point was reasonable, at >50%, and was comparable between the two regions. Although only just over half of these children had data for both occasions, these paired data were only used in adjusting for baseline differences, which, for prevalence of respiratory disease, was minimal, and this adjustment had little effect on the results. Participants were informed that they were taking part in a survey of ''health and diet'' but were not told of the hypothesis being tested, and were unaware of their ''control'' or ''intervention'' status, thus avoiding the potential reporting bias observed in conventional intervention studies [22]. Fruit juice intake was not assessed as this was not given as part of the NSFS, is not consistently associated with asthma in the literature and is also particularly difficult to quantify due to confusion with other fruit-flavoured drinks. A median baseline fruit intake of 8–10 pieces per week in the current 2003 study is higher than that reported in national UK surveys of ~6 pieces per week for children aged 5–7 yrs [23], which may reflect the relatively socially advantaged nature of the current study population as indicated by a median Townsend score of -1.3. This higher baseline fruit intake may be a contributing factor to the negative findings in the present study. The prevalence of asthma of ~13–14% is consistent with that seen in other comparable surveys [24].

In the context of previous cross-sectional studies suggesting that fruit consumption may be an important exposure influencing asthma symptoms in both children [3–5, 10, 11] and adults [6–9, 21], the absence of an effect of increase in fruit intake on measures of asthma symptoms requires consideration. There are several potential explanations for this. First, the duration of the intervention may have been too short, especially as the asthma outcome measures reflected symptoms over the previous 12 months, which encompassed the beginning of the period when fruit supplementation began in the East Midlands. Secondly, the population studied may not have been susceptible to the benefits of fruit supplementation,

TABLE 1 The distribution of sex, age and wheezing in the past 12 months for the study populations before and after fruit supplementation for 1 yr

	East Midlands (intervention)			Eastern region (control)		
	All respondents in 2003	All respondents in 2004	Respondents in both 2003 and 2004	All respondents in 2003	All respondents in 2004	Respondents in both 2003 and 2004
Subjects						
Total	5567	4971	3233	5995	5770	3506
Male	2837 (51.0)	2462 (49.6)	1607 (49.7)	3013 (50.4)	2851 (49.5)	1735 (49.5)
Female	2725 (49.0)	2506 (50.4)	1626 (50.3)	2971 (49.6)	2913 (50.5)	1771 (50.5)
Missing	5	3	0	11	6	0
Age in 2004 yrs						
5		821 (16.5)	525 (16.2)		964 (16.8)	533 (15.2)
6		2416 (48.7)	1590 (49.2)		2814 (48.9)	1757 (50.2)
7		1725 (34.8)	1118 (34.6)		1972 (34.3)	1208 (34.5)
Missing		9	0		20	8
Wheeze in past 12 months						
No	4753 (86.2)	4364 (88.1)	2797 (87.2)[#] 2850 (88.4)[¶]	5095 (85.7)	5065 (88.2)	3031 (86.9)[#] 3113 (89.1)[¶]
Yes	764 (13.8)	587 (11.9)	412 (12.8)[#] 374 (11.6)[¶]	851 14.3)	677 (11.8)	456 (13.1)[#] 382 (10.9)[¶]
Missing	50	20	24[#] 9[¶]	49	28	19[#] 11[¶]

Data are shown at the individual level, and are presented as n or n (%). [#]: 2003 data; [¶]: 2004 data.

which may be derived at a younger age when the immune system is less mature. This would be consistent with the data from a retrospective study from Norway, where starting to eat fruit under the age of 1 yr was associated with a 43% reduction in the diagnosis of asthma in a population with a mean age of 12–13 yrs [25]. Thirdly, the increase in fruit intake may not have been large enough (due to limited consumption of the free daily fruit or one piece of fruit a day not being sufficient) to impact on the pathophysiological processes that drive the development of asthma, and a greater increase in fruit intake may reduce asthma prevalence and severity. The collection of biomarkers would have permitted objective evaluation of fruit consumption, but unfortunately this was incompatible with the opportunistic study design that recruited a relatively large population of children. It is possible that the inability to adjust for factors that are associated with both diet and asthma in children, such as body mass index [26], may have resulted in residual confounding. Finally, the simple possibility has to be considered that there is no causal relationship between fruit intake and asthma and the previously reported observations are a consequence of confounding by other lifestyle factors.

In summary, the provision of daily fruit at school for 1 yr had no impact on the prevalence or severity of asthma symptoms in young children. Despite these observations, the provision of fruit to young children is a public health priority in view of the established health benefits of a diet rich in fruit [27–30].

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