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Childhood asthma and fruit consumption in South London

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ABSTRACT

We investigated whether wheezing is less common in children who consume more apples and other fruits.

We carried out a population based survey of 2640 primary school children aged 5-10 years in Greenwich, south London. Information about asthma symptoms and fruit consumption was obtained by questionnaire.

After controlling for potential confounders, eating bananas one or more times daily (compared to eating less than once a month) was negatively associated with current wheeze (odds ratio 0.66 (95% CI: 0.44, 1.00); p= 0.05), and with ever wheeze (OR 0.69 (0.50, 0.95); p=0.02), but not with ever asthma (OR 0.80 (0.56,1.14); p=0.22). Drinking apple juice from concentrate one or more times a day (compared to drinking less than once a month) was also negatively associated with current wheeze (OR 0.53 (34, 0.83); p=0.006), weakly associated with ever wheeze (OR 0.74 (- 0.54, 1.02); p= 0.07), but not associated with ever asthma. Consumption of apples, other fruits and orange juice was not significantly associated with asthma symptoms.

We found no association between eating fresh apples and asthma symptoms in this population, but found some evidence to suggest that a higher consumption of apple juice from concentrate, and bananas, may protect against wheezing in children.

Childhood asthma, Wheeze, Fruit, apples, South London

INTRODUCTION

The rise in the incidence, prevalence and associated medical and economic costs of asthma among children is a worldwide concern [1,2]. Repeat surveys in the United Kingdom have shown that the prevalence of current wheezing and diagnosed asthma in children remains high [3,4]. It has been suggested that the rise in asthma may partly reflect changes in population susceptibility resulting from alteration in diet, especially a fall in antioxidant intake, rather than increasing environmental toxicity [5]. A number of observational studies in adults have found an association between low fruit intake and asthma or lower lung function [6-11].

Our group has reported evidence for a protective effect of apple intake on adult asthma in Greenwich [8] and other communities in South East London (Sporik et al., 2003 - unpublished data). A few other studies in children have observed similar beneficial relations of higher fruit intake and improvement in lung function but not asthma symptoms [12-16]. We examined the relationship between consumption of apples and other fruits and prevalence of wheeze in a cross-sectional survey of young children attending primary schools in Greenwich, South London.

METHODS

Design

All the 64 schools included in the 2004/2005 Greenwich Primary schools list were invited to participate in this cross-sectional study. These comprised 46 community and 18 voluntary aided schools spread over the London Boroughs of Greenwich and Bromley. Of these 36 (56.3%) agreed to participate. Invitation letters, and information sheets explaining the study in more detail, were sent to parents or carers of 5-10 year old children (school years 2-5) in April 2005.

Data on asthma symptoms were collected by structured questionnaires, which were completed by parents and returned to us through their children's schools between April and June 2005. The questionnaire comprised sections on asthma symptoms and risk factors for childhood asthma. The asthma screening questions were based on the ISAAC questionnaire on asthma in children [17].

Definition of outcomes

Primary outcome measures were defined as follows:

Current wheeze: "Yes" to question "Has your child had wheezing or whistling in the chest in the last 12 months?"

*Wheeze ever: "*Yes" to question "Has your child ever had wheezing or whistling in the chest at any time in the past"?

*Ever asthma: "*Yes" to question "Has your child ever had asthma?"

Secondary outcomes included exercise related wheeze, sleep disturbance due to wheeze and nocturnal cough.

Definition of nutritional exposures: assessment of fruit intake

We assessed consumption of apples and other fruits in the previous 12 months by using a fruit frequency questionnaire. Based on previous studies [18,19], which had shown that food frequency measures are sensitive, we used relevant questions taken from a food frequency questionnaire used by our group previously [8]. Questions were asked to determine the intake of fresh apples, apple juice, bananas and other types of fruits. Secondary exposures of interest included soft, stoned, citrus, tinned and tropical fruit grouped together as miscellaneous fruit. Parents were asked to report how often, on average, their children had eaten specific fruit or drunk juices during the previous 12 months. Questions on apple juice distinguished between three types: freshly prepared apple juice, juice from concentrate and any other apple juice. For each fruit or juice type there were eight possible responses: more than once a day, once per day, 5-6 times per week, 2-4 times per week, once a week, 1-3 times per month, less than once per month, and never. Estimates of daily consumption of these fruit were then calculated as described by Carey et al. [20] To avoid baseline groups of less than 10%, and other small categories, we aggregated the groups as follows: consumption of fruit or juice less than once per month, once per month to once per week, two to six times per week and once or more per day.

Analysis

All analyses were carried out using the STATA statistical package version 8 (STATACorp, TX, USA). We used logistic regression to analyze the association between asthma symptoms and fruit consumption (in 4 levels, using 'less than once per month or never' as reference) after controlling for potential confounders.

Adjustment for confounders

For each fruit exposure (apples per day, pears per day, bananas per day, miscellaneous fruit per day, apple juice from concentrate per day, other apple juice per day, orange juice from concentrate per day, other orange juice/squash per day), we defined a propensity score[21, 22] , based on the following confounders: gender (male or female); age group (5-6, 7, 8, 9, 10-11 or unknown); paracetamol exposure group (<1 time per week, 1+ times per week or unknown); ibuprofen exposure group (<1 time per week, 1+ times per week or unknown); vitamin, iron or other supplement use (no, yes or unknown); child ever lived on a farm (yes, no or unknown); mould or mildew in child's bedroom (no, yes or unknown); mould/mildew in living areas (no, yes or unknown); mould/mildew in hallways (no, yes or unknown); mould/mildew in kitchen (no, yes or unknown); finance source for home repairs (family, landlord, housing association, council or unknown); child currently exposed to passive smoking (no, yes or unknown); child ever exposed to passive smoking (no, yes or unknown); child's ethnic group (White British, Black British, Black African, Black Caribbean, Asian-British, Asian, Other European, Other or Unknown); birth weight group in kilos (<2.5, [2.5,3), [3,3.5), [3.5,4), [4,4.5), 4.5+ or unknown); child breast-fed (no, yes or unknown); number of parents living with child (1, 2 or unknown); number of other children at home (0, 1, 2, 3, 4+ or unknown); mother's education level (primary school, secondary school, A levels, university, post-graduate or unknown); father's education level (primary school, secondary school, A levels, university, post-graduate or unknown).

The propensity score for each exposure was defined using a regression model of the exposure with respect to all the confounders, which was a generalized linear model

with a gamma variance function and an inverse link for miscellaneous fruit per day, and an ordinal logistic regression model for all other exposures. The values of each propensity score were grouped into 20 equal propensity groups. For each outcome and exposure, we fitted the parameters of 4 logistic regression models. These were an unadjusted per-unit model (containing a baseline odds for zero exposure and an odds ratio per unit exposure), a propensity-adjusted per-unit model (containing a baseline odds for zero exposure in each of the 20 propensity groups and a common per-unit odds ratio), an unadjusted grouped model (containing a baseline odds for zero exposure and an odds ratio for each non-zero exposure group), and a propensity-adjusted grouped model (containing a baseline odds for zero exposure in each of the 20 propensity groups and an odds ratio for each non-zero exposure group).

Ethics

Ethical approval was obtained from Bexley and Greenwich Local Research Ethics Committee. Heads of all participating schools also approved the survey.

RESULTS

The parents of 5470 primary school children were sent questionnaires to complete. A total of 2640 (48.3%) responded and returned completed questionnaires. Five of these children, whose ages and gender could not be determined, were removed from the analysis.

Asthma symptoms

Current wheeze was reported in 314 (11.9%) children; ever wheeze in 24.5%, and a history of ever having asthma in 18%. Exercise-induced wheeze was reported in 7.8% of children, and 9% of all children were reported as having both 'ever asthma' and current wheeze. Overall, 4% of the study population reported wheeze at least once a month, and 2.6% had sleep disturbance on one or more nights per week in the previous 12 months. Of those with current wheeze, 207 (66%) wheezed only three times or less in the preceding year.

Onset of asthma symptoms

A total of 51.5% of those with a history of asthma symptoms had their first asthma symptoms in infancy, 40% between 1 and 5 years, and 8.5% after 5 years of age.

Baseline characteristics

Table 1 shows the distribution of background characteristics of children whose parents responded. The mean age of pupils in the study was 8 years (range 5-11). Forty percent of children lived in a household where at least one adult had either smoked in the past or was currently smoking. In univariate analyses, living with a

smoker, being male, having a family history of asthma, being British, and lack of breastfeeding were significantly associated with a history of 'ever asthma'.

Fruit eating habits

Table 2 shows consumption of apples, apple juice and bananas by age, gender, ethnicity and parents' educational status. There were significant differences in the proportion of children taking at least a fruit or juice serving a day between ethnic groups, gender and according to parents' educational status, but not across age groups. White British children and those whose parents had less than 'A' level qualifications, consumed less fruit.

Frequency of Apple consumption

Table 3 and Figure 1 show the association between asthma symptoms and frequency of apple consumption. In univariate analyses, eating apples twice or more in a week, compared to eating less than once a month, was negatively associated with current wheeze, ever wheeze and ever asthma. With a propensity-adjusted model, these associations became less significant; whilst there was some evidence for a protective effect of eating apples two to six times per week compared with less than once a month, there was no evidence for a significant trend.

Apple Juice

In a multivariate logistic regression model, apple juice from concentrate was significantly negatively associated with current wheezing, and less strongly associated with ever wheezing, with evidence of a dose-response effect (Table 4). There was no significant relationship between other apple juice (Table 4), or orange juice

consumption (data not shown), and asthma symptoms after controlling for confounders.

Other fruits

Further analysis of other fruits (pears, and bananas, and miscellaneous fruits) showed that intake of bananas but not other fruits, was negatively associated with ever wheeze and current wheeze (Figure 1). There was a weak association with 'ever asthma'. However, there was no evidence of a dose-response effect. Analysis of intake of fruits as a continuous variable (per portion per day) showed no significant associations with asthma symptoms. The continuous adjusted OR for miscellaneous fruits (0.94 [95% CI 0.80, 1.0]), pears (0.89 [0.54, 1.45]) and bananas (0.85 [0.58, 1.24]) showed no significant protective effects against current wheeze. Similarly, there were no significant continuous effects for any of the fruits on ever wheeze or ever asthma (data not shown).

DISCUSSION

We have not found a relation between apple intake and asthma in this cross-sectional study in children. However, there is some evidence to suggest that children who have a higher consumption of apple juice from concentrate and bananas have a lower prevalence of current wheeze than children with a lower intake.

In contrast to studies in adults, [8,9] we have not been able to replicate a significant negative association between apple intake and asthma in children. Our negative findings are however, consistent with previous studies, which showed no clear relationship between wheezing in children and fresh fruit intake despite a beneficial effect on lung function [12-14]. It is not clear why the link observed in adult asthma was not replicated in children. The variation in the choice of outcome measures between studies, and in the validity and reliability of food frequency questionnaires in children, might have been responsible for these differences. Although use of similar questionnaires to collect data on dietary items was considered to be a sensitive method in previous studies [18, 19], none was validated in children. It is possible that the 'bluntness' of the fruit frequency questionnaire caused misclassification. This is especially likely in school age pupils in whom parents might not be able to account fully for fruit intake during school hours. It is also possible that the mild nature of disease in the population studied could have obscured or affected any relationship between fruit eating and asthma symptoms. Furthermore, the low response rate in this study could have biased the results obtained, and since we have no information on the difference between responders and non-responders, the direction and extent of such bias is uncertain.

This study observed that consumption of apple juice from concentrate was negatively associated with prevalence of current wheeze. Whilst this association may have occurred by chance, the strong dose response relation with current wheeze, and the weaker association with ever wheeze, favours a causal interpretation. Much of the protective effect of apples has previously been attributed to phytochemicals, which include flavonoids, isoflavonoids, and phenolic acids [23,24], and apples are the largest source of free phenolics in people's diet in the US and in Europe [25-28]. Thus flavonoids in apples and apple juice could plausibly reduce asthma inflammation and consequently lead to improvement in disease severity [8]. However, if this were the case, it is not clear why high consumption of fresh apples was not also negatively associated with asthma symptoms in this population. We had expected to see a stronger effect of fresh fruit intake than juice consumption, as studies have suggested that the processing of apples for juice results in a very significant decrease in phenolics [25,28]. However, a recent study has suggested that the increase in plasma antioxidant capacity after apple consumption may in fact be attributable to an increase in urate, rather than apple-derived antioxidant flavonoids, which tend to be poorly absorbed [29].

This survey incidentally found that banana intake might be beneficial for asthma symptoms. Bananas have long been recognized for their health benefit generally. For example, a recent study suggested an inverse relationship between cancer and banana intake [30, 31], but our study is the first to show a link between wheeze and intake of bananas in young children, although we did not see a clear dose-response relation. One explanation for this link might be their antioxidant content. Bananas have a higher content of bound-W phenolics than other fruits, including apples [30], and could plausibly reduce asthma inflammation. Furthermore, bananas have been shown

to increase the absorption of other nutrients, they are rich in provitamin A carotenoids which have been shown to protect against some chronic diseases [32, 33], and they are one of the best sources of potassium[34], which has been reported to be negatively related to lung volumes and flows in children [35].

Although we have controlled as rigorously as possible for potential non-nutritional confounders using propensity scores, we cannot exclude the possibility of residual confounding. Furthermore, some potential confounders, such as body mass index, and other foods and nutrients, were not measured in this study.

In conclusion, we were unable to show a link between eating fresh apples and asthma symptoms in this population of young children. Further studies are needed to confirm the protective effects of apple juice from concentrate and bananas observed in this study.

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*Competing interest*s: There is no competing interest to declare.

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Table 1. Distribution of baseline characteristics and their relation to the prevalence of 'ever asthma'

Characteristics	N (%)	Prevalence of 'ever asthma' (%)	p value *
Age group			
- 5-7 yrs	917 (35.5)	17.1	
- 8-9 yrs	1257 (49.1)	18.9	0.25
- 10-11 yrs	372 (14.7)	21.0	
- Unknown	21 (0.8)	-	
Gender			
Male	1235 (48.2)	22.0	
Female	1325 (51.8)	15.3	0.0001
History of breastfeeding			
Yes	1225 (59.6)	15.3	
No	791 (38.5)	24.2	0.0001
Don't know	38 (1.9)	0.0	
Birth weight: ≥2.5kg	1840 (92.1)	19.2	
: < 2.5	158 (7.9)	23.3	0.22
Parents' education			
- Secondary school or lower	565 (68.4)	23.2	0.001
- A levels or higher	261 (31.6)	13.4	
Family history of asthma			
Yes	690 (27.0)	32.5	
No	1836 (71.8)	13.5	0.0001
Unknown	30 (1.2)	13.3	
Number of siblings <16yrs			
- Nil	392 (16.2)	19.9	
- 1	955 (39.4)	19.4	0.66
- 2	715 (29.5)	18.6	
>= 3	360 (14.9)	16.7	
Ethnic groups			
- White British	1421 (58.9)	21.6	0.0001
- Other British	341 (14.1)	19.4	
- Others	649 (26.9)	11.9	
Exposure to tobacco smoke			
Yes	1021 (40.2)	22.4	0.0001
No	1517 (59.8)	16.0	

*p-value (chi^2 test) for difference in prevalence between groups.

Table 2. Fruit consumption by age, gender, race and parents' educational status

Baseline Characteristics	**Fruit consumed**					
	Number in the group and Proportion (%) taking at least a fruit serving (FS) per day					
	Fresh Apple		Apple juice γ		Banana	
	n	FS/day (%)*	n	JS/day (%)	n	FS/day (%)
Gender						
Male	1239	317 (25.6)	1215	263 (21.7)	1232	217 (17.6)
Female	1328	351 (26.4)	1305	287 (22.0)	1313	217 (16.5)
P (pearson chi^2)	p	0.04		0.73		0.81
Ethnic group						
White British	1439	349 (24.3)	1315	71 (5.4)	1434	185 (12.9)
Other British	344	90 (26.2)	310	42 (13.6)	339	66 (19.5)
Others	639	187 (29.3)	592	52 (8.8)	628	146 (23.3).
P (pearson chi^2	p	0.04		0.0001		0.0001
Parents' educational status						
< A level	1300	315 (24.2)	1277	214 (16.8)	1295	200 (15.4)
A level & above	1267	353 (27.9)	1248	337 (27.0)	1250	234 (18.7)
P (pearson chi^2)	p	*0.0001*		0.001		0.03
Age group						
5-6 years	258	64 (24.8)	239	11 (4.6)	257	41 (16.0)
7 years	657	170 (25.9)	597	56 (9.4)	647	116 (18.0)
8 years	659	160 (24.3)	603	47 (7.8)	652	106 (16.3)
9 year	600	173 (28.8)	546	38 (7.0)	597	104 (17.4)
10 & 11 years	374	94 (25.1)	346	35 (10.1)	373	61 (16.4)
P (pearson chi^2)	p	0.66		0.46		0.58

FS/day = Fruit serving per day; * Proportions of those eating at least one fruit serving a day; γAny apple juice serving (JS) per day

Table 3. Odds ratio for children's asthma symptoms associated with frequency of apple intake

Outcome	Frequency of apple consumption	Odds ratio$^{\phi}$, 95% CI and significance level		
		N	**Unadjusted OR (CI)**	**Adjusted OR (CI)**
Current Wheeze	< 1/month	165	1	1
	1/month-1/week	615	0.82 (0.51, 1.33)	0.82 (0.51, 1.33)
	2-6/week	1,090	0.62 (0.39 0.98)	0.64 (0.40, 1.02)
	1+/day	646	0.77 (0.47 1.24)	0.83 (0.50, 1.36)
	p-value (trend)		0.66	0.91
Ever Wheeze	< 1/month	165	1	1
	1/month-1/week	616	0.81 (0.56 1.17)	0.82 (0.56, 1.20)
	2-6/week	1092	0.62 (0.44, 0.89)	0.68 (0.47, 0.98)
	1+/day	651	0.68 (0.47, 0.99)	0.78 (0.53, 1.15)
	P-value (trend)		0.05	0.37
Ever Asthma	< 1/month	163	1	1
	1/month-1/week	606	0.83 (0.56, 1.24)	0.84 (0.56, 1.26)
	2-6/week	1081	0.50 (0.34, 0.74)	0.54 (0.36, 0.81)
	1+/day	644	0.69 (0.46, 1.03)	0.79 (0.52, 1.20)
	p-value (trend)		0.07	0.39

ϕ Compared to those consuming less than once a month

Figure 1. Plot of group adjusted odds ratios for asthma symptoms by frequency of consumption apples, pears, bananas and miscellaneous fruits (Reference group: < 1 serving per month).

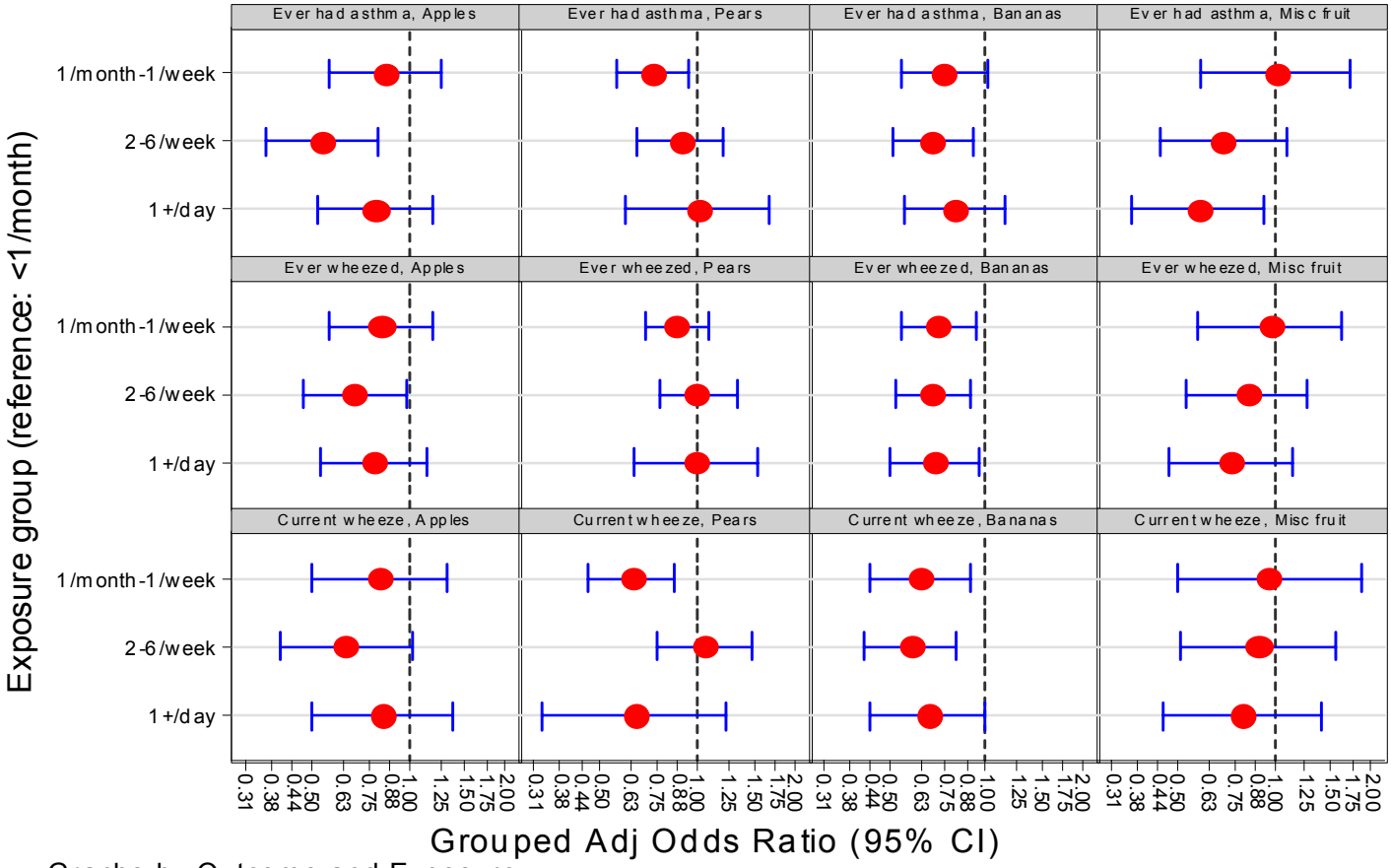

Table 4. Apple Juice consumption and asthma symptoms: unadjusted and adjusted odds ratio (OR)φ and 95% confidence interval.
(φ OR- compared to those drinking juice less than once monthly)

Exposure			Current wheeze		Ever wheeze		Ever asthma	
Fruit juice category		N (%)	**Unadj OR (95 % CI)**	**Adjusted OR 95 % CI)**	**Unadjust OR (95 % CI)**	**Adjust OR (95% CI)**	**Unadjust OR (95 % CI)**	**Adjusted OR (95% CI)**
Apple juice from conc.	**<1/month**	914 (39.0)	1	1	1	1	1	1
	1/mt - 1/week	611 (26.1)	0.86 (0.63, 1.16)	0.88 (0.64, 1.21)	0.83 (0.66, 1.05)	0.89 (0.70, 1.14)	0.79 (0.60, 1.03)	0.87 (0.66, 1.15)
	2-6 per week	443 (18.9)	0.61 (0.42, 0.88)	0.64 (0.44, 0.94	0.78 (0.60, 1.01)	0.86 (0.66, 1.14)	0.71 (0.52, 0.96)	0.82 (0.60, 1.12)
	1+ per day	377 (16.1)	0.51 (0.34, 0.78)	0.53 (0.34, 0.83)	0.63 (0.47, 0.85)	0.74 (0.54, 1.02)	0.70 (0.51, 0.97)	0.90 (0.63, 1.28)
	p-value for trend		**0.00079**	**0.003**	**0.002**	**0.055**	**0.018**	**0.400**
Other apple juice	**<1/month**	1156 (57.8)	1	1	1	1	1	1
	1/mt-1/week	393 (19.6)	0.84 (0.59, 1.21)	0.88 (0.61, 1.28)	0.82 (0.62, 1.07)	0.91 (0.69, 1.20)	0.79 (0.58, 1.07)	0.85 (0.62, 1.17)
	2-6 per week	254 (12.7)	0.91(0.59, 1.39)	0.93 (0.60,1.44)	0.73 (0.52, 1.02)	0.90 (0.63,1.28)	0.68 (0.47, 1.00)	0.79 (0.53, 1.17)
	1+ per day	198 (9.9)	0.60 (0.35, 1.02)	0.64 (0.35, 1.14)	0.64 (0.44, 0.94)	0.90 (0.63,1.28)	0.71 (0.47, 1.09)	0.95 (0.61, 1.49)
	p-value (trend)		**0.079**	**0.16**	**0.011**	**0.52**	**0.053**	**0.61**