Assessing smoking status in children, adolescents and adults: cotinine cutpoints revisited.

Martin J Jarvis,
Jennifer Fidler
Health Behaviour Research Centre
Department of Epidemiology and Public Health
University College London

Jennifer Mindell
Department of Epidemiology and Public Health
University College London

Colin Feyerabend
Medical Toxicology Unit, New Cross Hospital

Robert West,
Health Behaviour Research Centre
Department of Epidemiology and Public Health
University College London

3123 words in text

Correspondence to: Professor Martin Jarvis, Department of Epidemiology and Public Health, University College London, 2-16 Torrington Place London WC1E 6BT

Abstract

Aims: To reassess saliva cotinine cut-points to discriminate smoking status. Cotinine cut-points that are in use were derived from relatively small samples of smokers and non-smokers 20 or more years ago. It is possible that optimal cut-points may have changed as prevalence and exposure to passive smoking have declined.

Design: Cross-sectional survey of the general population, with assessment of self-reported smoking and saliva cotinine.

Participants: A total of 58,791 respondents aged 4 and older in the Health Survey for England for the years 1996-2004 who provided valid saliva cotinine specimens.

Measures Saliva cotinine concentrations, demographic variables, self-reported smoking, presence or absence of smoking in the home, a composite index of social disadvantage derived from occupation, housing tenure and access to a car.

Findings: A cut-point of 12 ng/ml performed best overall**,** with specificity of 96.9% and sensitivity of 96.7% in discriminating confirmed cigarette smokers from never regular smokers. This cut-point also identified 95.8% of children aged 8-15 smoking 6 or more cigarettes a week correctly. There was evidence of substantial misreport in claimed ex-smokers, especially adolescents (specificity 72.3%) and young adults aged 16-24 (77.5%). Optimal cut-points varied by presence (18 ng/ml) or absence (5 ng/ml) of smoking in the home, and there was a gradient from 8 ng/ml to 18 ng/ml with increasing social disadvantage.

Conclusions: The extent of non-smokers' exposure to other people's tobacco smoke is the principal factor driving optimal cotinine cut-points. A cut-point of 12 ng/ml can be recommended for general use across the whole age range, although different cut-points may be appropriate for population subgroups and in societies with differing levels of exposure to secondhand smoke.

Introduction

Self-reported smoking status may not always be reliable, particularly when there is perceived social pressure not to smoke [1 2]. Biochemical markers of smoke intake have proved useful in validating self-reports of cessation and for groups, such as pregnant women and hospital patients, where misreports appear common [2]. Objective indicators of smoking are also of value in surveys of smoking in the general population to provide unbiased estimates of prevalence [3]. Cotinine is generally accepted to be the best of the available markers, with specificity (percentage of non-smokers classified as non-smokers) and sensitivity (percentage of smokers classified as smokers) both over 95%. A cut-point of about 15 ng/ml for either plasma or saliva cotinine to discriminate current smokers from non-smokers has been widely applied [2 4 5]. However, these cut-points were derived 20 or more years ago from relatively small samples of smokers and non-smokers.

Although there may be some minimal intake of nicotine from dietary sources [6], for all practical purposes nicotine can be regarded as specific to use of tobacco. Measured concentrations of nicotine (or of cotinine, its principal metabolite) therefore reflect active tobacco smoking, passive smoking, use of non-combustible tobacco products, or use of pharmaceutical nicotine. This being the case, in the absence of second-hand smoke, cotinine would be at close to undetectable levels in non-users of tobacco, and even very low concentrations of cotinine would be diagnostic of recent tobacco use. On this argument, as levels of exposure to passive smoking in the population have decreased over the years [7 8], optimal cut-points for detecting current tobacco use could have shifted to lower levels. However, it has also been suggested that optimal cut-points depend on the prevalence of smoking in the population under study, and should be relatively higher when the prevalence of smoking is low, and lower when smoking is common[9]. The suggestion is that when the prevalence of smoking is low, the number of misclassifications will depend primarily on the false-

positive rate of the test. Thus the optimal cut-point should then be higher to minimize the false-positive rate. Since the prevalence of smoking has declined substantially over the past 20 years, this would appear to indicate that higher, rather than lower, cut-points might now be appropriate.

We have used data from the Health Survey for England to re-examine optimal cut-points for saliva cotinine. We have taken advantage of the large amount of available data to estimate cut-points by age group (children, adolescents and adults), and in groups stratified by the level of socio-economic disadvantage and by the presence or not of smoking in the household to explore the impact of different levels of cigarette smoking prevalence and differing extents of exposure to other people's smoke.

Methods

The Health Survey for England is an annual survey designed to generate a representative sample of the population living in private households in England. Using the Postcode Address File (PAF) as the sampling frame, a stratified random sample of households is identified. Adults and up to 2 children in eligible households are interviewed in the home, followed by a nurse visit to take biological measures about 1 week later. Smoking habits are ascertained in detail at the interview, and reassessed briefly at the nurse visit, when saliva samples for determining cotinine levels are also taken. Saliva specimens for cotinine were collected from children aged between 4 and 15 from 1996 onwards, and from adults from 1998. We combined data for the years from 1996 to 2004, including all adult and child respondents for these years with valid cotinine samples (but excluding those who were current users of nicotine replacement products), resulting in a file on a total of 58,791 respondents . Full details of survey methodology and response rates for each year are available in published reports [10-18] and online [19].

Smoking habits

Self-reported smoking habits in adults were ascertained by individual interview using a computer aided schedule. Those aged 16-17 years (and some aged 18-19 years) were given a self-completion booklet for greater confidentiality. Current and lifetime cigarette, pipe and cigar smoking were assessed, as well as usual rate of consumption in current cigarette smokers. The screening question for current cigarette smoking was "Do you smoke cigarettes at all nowadays?" Questions relating to use of oral tobacco products were asked only in 1999 and 2004, when there was a focus on minority ethnic groups, and then only of respondents from the Indian subcontinent. Use of nasal snuff was not assessed. Children aged from 8 to 15 were also given self-completion booklets and were asked to identify their smoking on a 6 item scale: "I have never smoked"; "I have only smoked once or twice"; "I used to smoke sometimes, but I never smoke a cigarette now"; "I sometimes, smoke, but I don't smoke every week"; "I smoke between one and six cigarettes a week"; "I smoke more than six cigarettes a week". There was no attempt to assess smoking in children aged under 8.

At the nurse visit, there was a further single screening question for smoking which was asked of all adults "Can I ask, do you smoke cigarettes, cigars or a pipe at all these days?" In addition, self-reported smokers were asked when they last smoked (within the past day vs. more than 24 hours ago).

Saliva sample

The nurse attempted to collect a saliva sample from all adults by asking them to keep a dental roll in their mouths until it was saturated and then replace it in the sample tube. Children aged under 8 were given a straw to dribble saliva through into a sample tube.

Cotinine assay

Cotinine was assayed by a widely applied gas chromatographic method with a detection limit of 0.1 ng/ml [20]. Regular internal quality controls were run to ensure comparability and reliability of results over time.

A summary index of socioeconomic disadvantage was computed at the level of the household by combining information on occupational class, access to a car, and housing tenure. Each of the following was scored as either 0 or 1: head of household's occupation non-manual (0)/manual (1); access to a car (0)/ no car(1); owner-occupied housing(0)/rented (1). Thus the total score ranged from 0 in the most affluent households to 3 in the most deprived.

At the initial interview, the question was asked "Does anyone smoke inside this house/flat on most days?" The response to this was used to identify households as exposed or not to passive smoking.

Statistical analysis

We determined optimal cut-points by finding the cotinine value which assigned the greatest percentage of respondents correctly, taking self-report as the criterion, and giving equal weight to smoking and non-smoking (i.e. optimizing the total percentage correctly assigned, rather than the absolute numbers). As a check to see whether this weighting altered cut-points significantly, we also determined cut-points that maximized the absolute number of self-reported non-smokers and smokers correctly assigned.

We employed three operational definitions of current smoking status, in order of increasing stringency:

1. Self-report of any smoking (cigarettes, pipes or cigars "at all these days") at the nurse visit vs. denial of smoking at the nurse visit;

2. Self-report of cigarette smoking at the nurse visit vs. denial of smoking at the nurse visit;

3. Reported cigarette smoking at both initial interview and nurse visit vs. never regular smoking at initial interview confirmed by denial of smoking at the nurse visit. By excluding self-reported ex-smokers, this focused on the group of non-smokers among whom self-reports are least likely to be unreliable.

Results

The distribution of respondents by age and smoking habits is given in Table 1. Reported cigarette smoking prevalence at initial interview was 27.5%, close to the observed prevalence for all adults in Britain in these years[21], and showed the expected gradient with social disadvantage, ranging from 19% in the most affluent to 45% in the most deprived. There was a more extreme variation in prevalence in groups defined by the presence or absence of smoking in the home – 70% among those from smoking homes versus 8% in those from non-smoking homes. Among adolescents aged 12-15, 7.5% reported current smoking, and there was a gradient in both never smoking (75% down to 61%) and current smoking (5% up to 12%) by increasing social disadvantage. The great majority of children aged 8-11 were never smokers (95%), with minimal reported current smoking (0.2%). This provides support for the assumed non-smoking status of children aged 4-7, in whom smoking was not assessed.

Table 2 shows optimal cut-points among adults for saliva cotinine for our three operationally defined smoking categories, and by deprivation and smoking in the home. Among all respondents, the optimal cut-point for discriminating any smoking at the nurse visit was 11 ng/ml, with specificity of 95% and sensitivity of 94.1%. This cut-point was the same for detecting cigarette smoking at the nurse visit, but sensitivity improved to 95.7%. The optimal cut-point for the most stringent definition of smoking (cigarette smoking at both interview and nurse visit versus never regular smoking at interview and no smoking at nurse visit) was slightly higher, at 12 ng/ml, with improvements in both specificity (96.9%) and sensitivity (96.7%).

Table 2 also indicates that optimal cut-points varied substantially among subgroups defined either by smoking in the home or by level of social disadvantage. Thus the optimal cut-point for respondents from non-smoking homes was 5 ng/ml, substantially lower than the 18 ng/ml cut-point for those from smoking homes. Similarly, there was a gradient in optimal cut-points with social disadvantage, rising from 8 ng/ml in the most affluent to 18 ng/ml in the most disadvantaged. These cut-points in subgroups differed little for the three operationally defined smoking categories. Figures 1 and 2 show the distributions of cotinine for adult never regular smokers and confirmed cigarette smokers by social disadvantage (Fig 1) and smoking in the home (Fig 2).

Cut-points calculated to maximize the absolute numbers of respondents correctly classified showed rather little difference from those that maximized the sum of the percentages of smokers and nonsmokers. The optimal cut-point overall remained at 12 ng/ml, and ranged from 9ng/ml (specificity 97.7%, sensitivity 96.2%) in the least socially disadvantaged group to 13 ng/l (specificity 92.1%, sensitivity 97.6%) in the most disadvantaged.

The data presented in Table 2 and in the Figures demonstrate clearly that a single cut-point cannot accurately characterize all population subgroups. However, although optimal cut-points displayed substantial variation, the difference in the percentage correctly assigned was quite limited across a range of cut-points. It is also the case that most investigators will be concerned with samples drawn from the general population rather than from particular subgroups. In further analyses we therefore explored specificity and sensitivity associated with the 12 ng/ml cut-point.

Table 3 shows specificity by age group, together with the observed median and interquartile ranges of cotinine observed in respondents above the cut-point. Specificity was 98% in children aged 4-7, with a lower figure (94.8%) in those from smoking homes or from the most disadvantaged backgrounds (95.1%). An examination of cotinines in these children shows that most who were above the cut-point had values that were only modestly raised (median 17 ng/ml). This suggests that in the great majority of cases their cotinine levels may have been attributable to heavy passive smoking rather than to active smoking. Findings were similar in children aged 8-12 (99.1% specificity, and most raised values still compatible with passive exposure). However, specificity reduced to only 89% in young adults aged 16-24, and cotinine values above the threshold were mostly not compatible with passive smoking. This was also the case in older age groups, among whom the median cotinine above the cut-point was invariably well into the smoking range.

Table 4 shows specificity for self-reported ex-smoking. There was evidence of substantial levels of misreporting, particularly among younger respondents. Specificity was 72.3% in those aged 8-15 and 77.5% in 16-24 year old, and rose with age to 96.8% in those aged 65 and above. Cotinine concentrations, which were typically well into the smoking range, indicated that at all ages lowered specificity was due almost entirely to misreport rather than to heavy passive exposure. There was

some tendency, though relatively weak, for specificity to be lower in those from smoking homes or disadvantaged backgrounds.

Sensitivity for self-reports of current smoking in children aged 8-15 are shown in Table 5. Sensitivity was 37.4% among those who reported smoking less frequently than weekly, rising to 85.7% in those smoking 1-6 cigarettes a week, and 95.8% in those smoking more than 6 cigarettes per week. Sensitivity, particularly at lower consumption levels, was higher in those from smoking homes or disadvantaged backgrounds.

Sensitivity for self-reported cigarette smoking in adults is given in Table 6, by levels of cigarette consumption and by whether or not respondents said they had smoked within the past day. Sensitivity was 56.4% in those whose reported usual daily consumption was zero or less than 1 cigarette, and 86.6% in those smoking 1-4 cigarettes a day. In both cases, sensitivity was markedly higher (82.9% and 94.5%) in those who reported smoking in the past 24 hours. In groups with consumption of 10 or more cigarettes a day, almost all of whom had smoked in the past day, sensitivity was close to 100%.

Discussion

Our findings indicate that a saliva cotinine cut-point of 12 ng/ml performs well in all age groups in discriminating self-reported non-smokers from smokers. This cut-point is somewhat lower than that currently recommended [2]. Specificity and sensitivity were both about 97%. Our study was based on very large samples drawn from the general population, giving confidence that the 12 ng/ml cut-point can be recommended for widespread application.

We found that optimal cut-points varied by the level of cigarette smoking prevalence, and were lower in subgroups with low prevalence and higher where smoking was common. This indicates that investigators should give consideration to the group they are studying when choosing an appropriate cut-point. However, since most studies will have subjects drawn from a range of social backgrounds, the 12 ng/ml cut-point is likely to be generally applicable. It is also the case that cut-point performance varied only slightly across a range of cotinine values from 6 to 18 ng/ml.

Three types of error in categorizing individuals' smoking status can be identified: false positives (non-smokers classified as smokers); false negatives (smokers classified as non-smokers); and random or measurement error resulting in either false positives or false negatives. The extent of measurement error would appear to be small, as indicated by the 99.7% specificity for non-smoking in children aged under 12 from non-smoking homes. The remaining 0.3% categorized as smokers represents the maximum extent of false positives due to measurement error, although the possibility that some of these young children were indeed using tobacco cannot be excluded.

False negatives are not of great concern, as if people say they smoke, they are believed, and it seems unlikely that many true non-smokers would falsely claim to be smokers. Some smokers are likely to be classified as non-smokers at any cut-point, as they may smoke so infrequently or not inhale sufficiently to generate raised cotinine concentrations. However, the extent of such ultra-light smoking appears to be minimal. Among adults, 95% of self-reported cigarette smokers had smoked in the past day, and 99% of these were identified as smokers. Among the small minority who had not smoked in the past day, over 60% were nevertheless classified as smokers. This suggests that true occasional or non-inhaled smoking is something of a rarity in adults. In a similar vein, children smoking over 6 cigarettes a week were almost always identified as smokers, and even among those

who reported smoking less frequently than one cigarette a week, close to 40% were correctly classified as smokers.

False positives constitute the most important form of misclassification. Most non-smokers currently have measurable concentrations of cotinine from breathing other people's smoke, and in some cases the exposure is sufficiently great to result in a cotinine above the smoking cut-point. Children aged under 12 are a case in point. Some 1.4% in this age range were above the 12 ng/ml cut-point for smoking, but in most cases their cotinine concentration was only slightly raised above the cut-point, and it is likely that heavy exposure to passive smoking rather than active smoking was the cause. It is known that young children are more heavily exposed to secondhand smoke than any other age group[7]. It has previously been suggested that a cotinine value of 20 ng/ml is close to the upper limit achievable through passive smoking [22]. The present findings support this.

We found that optimal cut-points were lower in groups with low smoking prevalence, and higher where prevalence was raised. This is directly contrary to Cumming's proposal [9], and suggests instead that the principal factor driving the level of the cut-point is the extent of non-smokers' exposure to tobacco smoke. As smoking becomes increasingly restricted in public places and in the home, non-smokers' exposure declines and the optimal cut-point becomes lower. Our cut-point of 12 ng/ml (corresponding to a plasma cotinine cut-point of about 9.5 ng/ml[23]) represents a considerable reduction from the previous recommended level of 15 ng/ml, and speaks to the progress that has been achieved in reducing non-smokers' exposure. It follows from our findings that optimal cut-points are likely to be country specific. Where exposure to secondhand smoke is low, as in the USA, cut-points could be lower, and higher in countries where there is still heavy smoke pollution

inside and outside the home. As smoking declines and with it passive exposure, there will be a need to re-evaluate cut-points in the future.

Our study has some limitations. In most years, and from the great majority of respondents, there was no attempt to ascertain use of non-combustible tobacco products. This may have resulted in some reduction in specificity in claimed non-smokers. Overall specificity was 96.9%, but it was 98.4% in white respondents as against 90.2% in people from South Asia. This difference could well reflect the high prevalence of oral tobacco use among those from India, Pakistan and Bangladesh. There may also have been demand factors affecting the accuracy of self-report. It was notable that misreports were most common in adolescents and young adults, with evidence of continued smoking in up to a quarter of claimed ex-smokers. This could be due to an unwillingness to reveal smoking in the presence of parents, despite the use of self-completion booklets for extra privacy.

There is a continuing need for biochemical measures of smoking to supplement and validate self-report. We found evidence of substantial levels of misreport in claimed ex-smokers, especially in younger respondents, and it is possible that estimates of cigarette smoking prevalence based on self-report may become increasingly unreliable as the social acceptability of smoking declines. Our findings show that saliva cotinine offers a firm base for objective measures of smoking status.

References

1. Jarvis M, West R, TunstallPedoe H, Vesey C. An evaluation of the intervention against smoking in the multiple risk factor intervention trial. *Preventive Medicine* 1984;13(5):501-509.
2. Benowitz N, Jacob P, Ahijevych K, Jarvis M, Hall S, LeHouezec J, et al. Biochemical verification of tobacco use and cessation. *Nicotine and Tobacco Research* 2002;4:149-159.
3. West R, Zatonski W, Przewozniak K, Jarvis MJ. Can we trust national smoking prevalence figures? Discrepancies between biochemically assessed and self-reported smoking rates in three countries. *Cancer Epidemiol Biomarkers Prev* 2007;16(4):820-2.

4. Jarvis MJ, TunstallPedoe H, Feyerabend C, Vesey C, Saloojee Y. Comparison of tests used to distinguish smokers from nonsmokers. *American Journal of Public Health* 1987;77(11):1435-1438.
5. McNeill AD, Jarvis MJ, West R, Russell MA, Bryant A. Saliva cotinine as an indicator of cigarette smoking in adolescents. *Br-J-Addict* 1987;82(12):1355-60.
6. Jarvis MJ. Dietary nicotine won't mislead on passive smoking unless subjects eat 90 kg tomatoes a day. *British Medical Journal* 1994;308(6920):62.
7. Royal College of Physicians. Going smoke-free: The medical case for clean air in the home, at work and in public places. London: Royal College of Physicians, 2005.
8. Jarvis M, Goddard E, Higgins V, Feyerabend C, Bryant A, Cook D. Children's exposure to passive smoking in England since the 1980s: cotinine evidence from population surveys. *Br Med J* 2000;321:343-345.
9. Cummings SR, Richard RJ. Optimum cutoff points for biochemical validation of smoking status. *Am-J-Public-Health* 1988;78(5):574-5.
10. Prescott-Clarke P, P. P. The health of Young People '95-97 Vol 2 Methodology and Documentation. London: The Stationery Office, 1998.
11. Prescott-Clarke P, Primatesta P. Health Survey for England '96 Vol 2 Methodology and documentation. London: The Stationery Office, 1998.
12. Erens B, Primatesta P, editors. *Health Survey for England: Cardiovascular Disease '98.* London: The Stationery Office, 1999.
13. Erens B, Primatesta P, Prior G, editors. *Health Survey for England: The Health of Minority Ethnic Groups 1999. Volume 2 Methodology & Documentation*. London: The Stationery Office, 2001.
14. Prior G, Teers R, Brookes M, Primatesta P. Health Survey for England 2000: Methodology and documentation. London: The Stationery Office, 2002.
15. Prior G, Deverill C, Malbut K, Primatesta P. *Health Survey for England 2001: Methodology and documentation*. London: The Stationery Office, 2003.
16. Sproston K, Primatesta P. Health Survey for England 2002. Volume 3: Methodology and Documentation. London: The Stationery Office, London, 2003.
17. Sproston K, Primatesta P. Health Survey for England 2003 Volume 3: Methodology and documentation. London: The Stationery Office, 2004.
18. Sproston K, Mindell J. Health Survey for England 2004. Volume 2: Methodology and dcumentation. London: National Centre for Social Research, 2006.
19. Department of Health. Health Survey for England., www.dh.gov.uk/en/Publicationsandstatistics/PublishedSurvey/HealthSurveyForEngland/index.htm
20. Feyerabend C, Russell MAH. A rapid gas-liquid chromatographic method for the determination of cotinine and nicotine in biological fluids. *Journal of Pharmacy and Pharmacology* 1990;42(6):450-452.
21. Goddard E. General Household Survey 2005: smoking and drinking among adults, 2005. London: Office for National Statistics, 2006.
22. Jarvis MJ. Application of biochemical intake markers to passive smoking measurement and risk estimation. *Mutation Research* 1989;222(2):101-110.
23. Jarvis MJ, Primatesta P, Erens B, Feyerabend C, Bryant A. Measuring nicotine intake in population surveys: comparability of saliva cotinine and plasma cotinine estimates. *Nicotine and Tobacco Research* 2003;5:349-355.

Table 1

Distribution of smoking habits by age, by deprivation and by presence of smoking in home

Age group	n	Smoking habits	Household deprivation					Smoking in home?			All respondents
			0	1	2	3		Yes	No		
4-7	*6619*	*Assumed non-smoking*	-	-	-	-		-	-		-
8-12	*7554*	Never smoked %	96.7	95.3	90.9	89.6		90.7	96.9		94.6
		Any current smoking %	0.1	0.3	0.3	0.4		0.3	0.2		0.2
12-15	*6984*	Never smoked %	74.6	69.5	63.6	60.8		58.1	74.3		68.4
		Any current smoking %	5.4	6.7	9.6	12.2		12.7	4.6		7.5
16+	*37634*	Current cigarettes %	19.2	27.5	38.6	45.4		69.6	8.2		27.5
16-24	*6123*		31.9	33.5	45.0	53.8		61.7	20.8		37.4
25-34	*6486*		24.8	34.3	47.0	51.4		75.8	12.7		34.5
35-44	*7579*		20.0	30.3	47.5	56.3		76.0	8.0		29.8
45-54	*6344*		17.3	28.5	43.3	57.0		69.4	5.2		26.5
55-64	*4867*		14.5	22.0	35.3	48.0		64.5	4.0		22.3
65+	*6235*		8.2	13.5	15.8	24.2		61.9	1.9		13.6

Table 2
Optimal cutpoints for all adults, and by deprivation and presence of smokers in the household

	Any smoking vs. no smoking at nurse visit					Cigarettes vs. no smoking at nurse visit					Cigarettes at interview + nurse visit vs. never smokers				
	N	**% smoke**	**Cutpoint (ng/ml)**	**specificity**	**sensitivity**	***N***	**% smoke**	**Cutpoint (ng/ml)**	**specificity**	**sensitivity**	***N***	**% smoke**	**Cutpoint (ng/ml)**	**specificity**	**sensitivity**
Deprivation															
0	*15036*	18.4	8	95.8	92.8	*14753*	16.8	8	95.8	95.3	*9203*	25.3	8	97.5	96.5
1	*13595*	26.2	10	94.7	94.8	*13416*	25.2	11	94.9	95.8	*8865*	36.2	12	97.3	96.9
2	*6182*	36.9	14	93.0	95.9	*6110*	36.2	17	93.4	96.3	*4255*	49.6	15	94.8	97.2
3	*2816*	43.8	17	91.9	95.8	*2783*	43.2	18	92.0	96.2	*2009*	57.5	18	92.6	97.3
Smoking in home?															
No	*26274*	8.5	5	94.7	87.6	*25997*	7.6	6	95.1	90.6	*15176*	10.8	5	96.6	94.1
Yes	*11340*	67.0	18	89.4	96.7	*11050*	66.1	18	89.3	97.2	*9147*	78.3	18	93.8	97.5
All adults	*37629*	26.2	11	95.0	94.1	*37062*	25.0	11	94.9	95.7	*24332*	36.2	12	96.9	96.7

Table 3

Specificity % for non-smoking by self-report by age group for a saliva cotinine cutpoint of 12 ng/ml

Age group	N	All			Smoker in home?					Deprivation level			
		All %	Cotinine median, interquartile range in those above cut-point		Yes %	Cotinine interquartile range in those above cut-point	No %	Cotinine interquartile range in those above cut-point		0 %	1 %	2 %	3 %
4-7	*6618*	98.0	16.8, 13.9-26.2		94.8	13.7-23.5	99.7	23.8-341		99.4	98.5	95.7	95.1
8-11	*7052*	99.1	16.3, 13.0-36.2		98.1	12.6-26.5	99.7	16.7-93		99.7	99.6	97.8	97.1
12-15	*5883*	94.9	65.8, 25.8-162		90.9	25.4-182	97.0	25.8-113		97.3	94.6	92.3	87.2
16-24	*4234*	89.3	65.6, 28.5-156		84.4	32-172	91.0	26.4-139		89.5	89.9	88.3	86.5
25-34	*4380*	94.4	82.8, 31.3-216		86.3	46-254	95.7	27.6-191		96.2	94.9	90.7	87.8
35-44	*5402*	95.6	129.8, 40-275		88.7	75-353	96.5	34-230		97.2	95.4	91.4	88.6
45-54	*4667*	96.5	151.5, 48-317		92.2	41-326	97.2	49-317		97.7	95.9	93.6	91.9
55-64	*3746*	96.6	118.4, 47-293		91.3	69-297	97.4	38-267		97.7	96.7	94.9	88.8
65+	*5343*	97.1	117.2, 36-266		89.0	22.5-332	97.7	44-241		97.9	97.5	95.8	95.7

Note: All children aged under 8 assumed to be non-smokers; children aged 8-15 reported either never smoking a cigarette or having tried a cigarette, but no current smoking; adults aged 16+ responded no to the question ‘Can I ask, do you smoke cigarettes, cigars or a pipe at all these days?’ at the nurse visit. Saliva for cotinine assay was taken at the nurse visit. Self-reported users of nicotine replacement products were excluded. Use of snuff and chewing tobacco was not assessed. Smoking behaviour was assessed in children aged 8-15, and also in young adults aged 16-17, by self-completion questionnaire at the initial interview.

Cotinine interquartile ranges are given for those respondents whose cotinine was above the cutpoint for smoking.

Table 4

Specificity % for self-reported ex-smoking by age group for a saliva cotinine cutpoint of 12 ng/ml

Age group	N	All	Cotinine median (ng/ml), interquartile range in respondents classified as smoking		Smoker in home?			Deprivation level			
		All			Yes	No		0	1	2	3
8-15	*441*	72.3	91, 44-145		68.9	75.4		74.6	68.9	77.4	72.4
16-24	*280*	77.5	65, 28.5-156		65.3	81.7		81.6	74.2	76.8	77.8
25-34	*764*	90.2	86, 31.3-216		87.2	90.6		92.3	88.9	87.7	90.3
35-44	*1184*	93.2	99, 40-275		95.4	92.8		95.2	92.3	90.9	82.5
45-54	*1512*	95.3	116, 48-317		95.3	95.3		95.9	94.8	93.1	97.4
55-64	*1570*	96.1	114, 47-293		95.0	96.2		97.0	95.2	95.7	94.7
65+	*2581*	96.8	79, 36-266		90.4	97.4		97.3	97.5	96.1	94.7

Note: Ex-smoking children aged 8-15 were those who responded by self-report questionnaire at initial interview “I used to smoke cigarettes sometimes, but I never smoke now”. Adult ex-smokers were those who reported being ex-regular cigarette smokers (and not current smokers of cigars/pipes) at initial interview, and who also denied smoking of any tobacco product at the nurse visit (No to ‘Can I ask, do you smoke cigarettes, cigars or a pipe at all these days?’)

Table 5

Sensitivity % for self-reported smoking among children aged 8-15 for a saliva cotinine cutpoint of 12 ng/ml

Cigarette consumption category	N	All	Cotinine median (ng/ml), interquartile range in respondents classified as smoking		Smoker in home?			Deprivation level			
					Yes	No		0	1	2	3
<1 cig/week	*182*	37.4	109, 46-190		52.3	23.4		29.7	37.9	51.6	36.4
1-6 cigs/week	*84*	85.7	107, 68-202		91.5	78.4		74.2	92.0	90.5	100
>6 cigs/week	*259*	95.8	184, 95-266		96.8	93.2		93.5	100	94.1	94.7
Any current smoking	*525*	73.9	155, 78-247		83.8	58.3		63.7	73.9	83.9	76.1

Table 6

Sensitivity % at cutpoint of 12ng/ml for self-reported smoking by usual consumption and whether or not smoked in past 24 hours

			Smoked in past 24hrs		No smoking in past 24 hrs	
Usual cigarette Consumption	n	sensitivity	n	sensitivity	n	sensitivity
<1	*195*	56.4	*76*	82.9	*119*	39.5
1-4	*882*	86.6	*673*	94.5	*208*	61.1
5-9	*1461*	97.5	*1354*	99.0	*107*	78.5
10-14	*2105*	99.2	*2077*	99.4	*28*	85.7
15-19	*1463*	99.2	*1457*	99.2	*6*	83.3
20+	*2653*	99.5	*2645*	99.5	*8*	75.0
ALL	*8759*	96.8	*8282*	98.8	*476*	61.6

Respondents who reported smoking cigarettes at both the initial interview and the nurse visit. Usual cigarette consumption was assessed at initial interview. Respondents were asked whether or not they had smoked in the past 24 hours at the nurse visit, when the saliva specimen for cotinine was also collected.

Figure legends

Figure 1

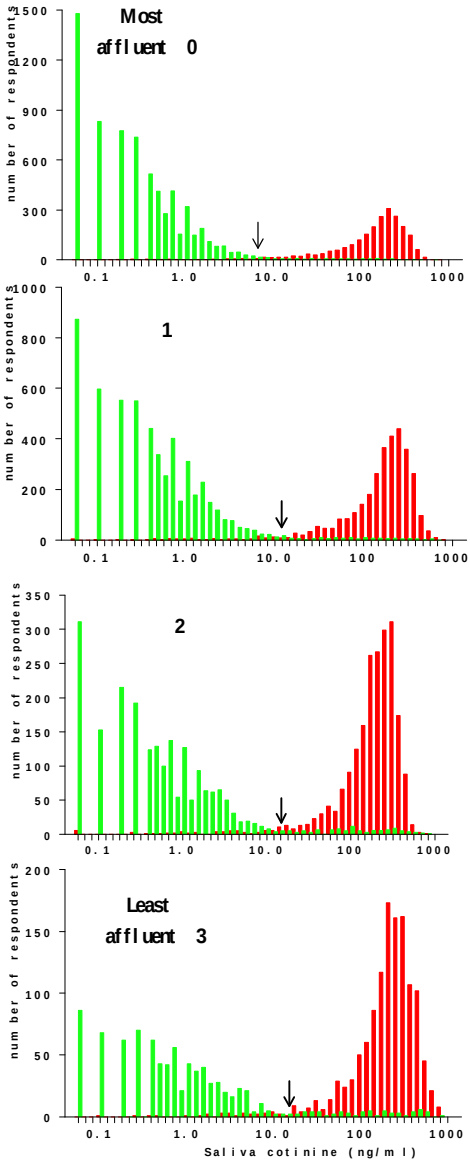
Distribution of saliva cotinine in non-smokers and smokers by degree of social disadvantage

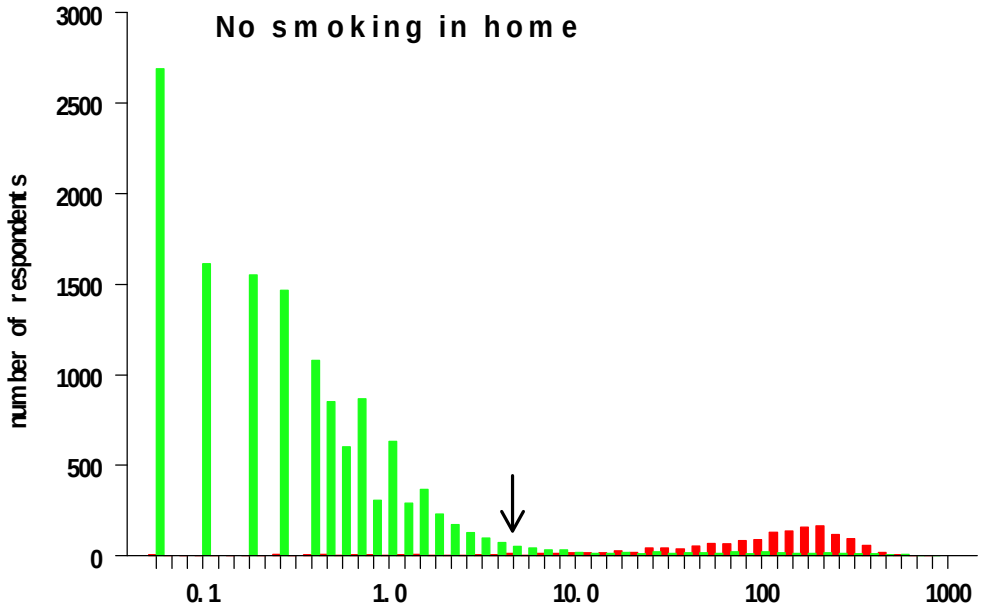
Smokers (in red): self-reported cigarette smoking at initial interview and at nurse visit; non-smokers (in green): never regular smokers at initial interview + denial of smoking at nurse visit

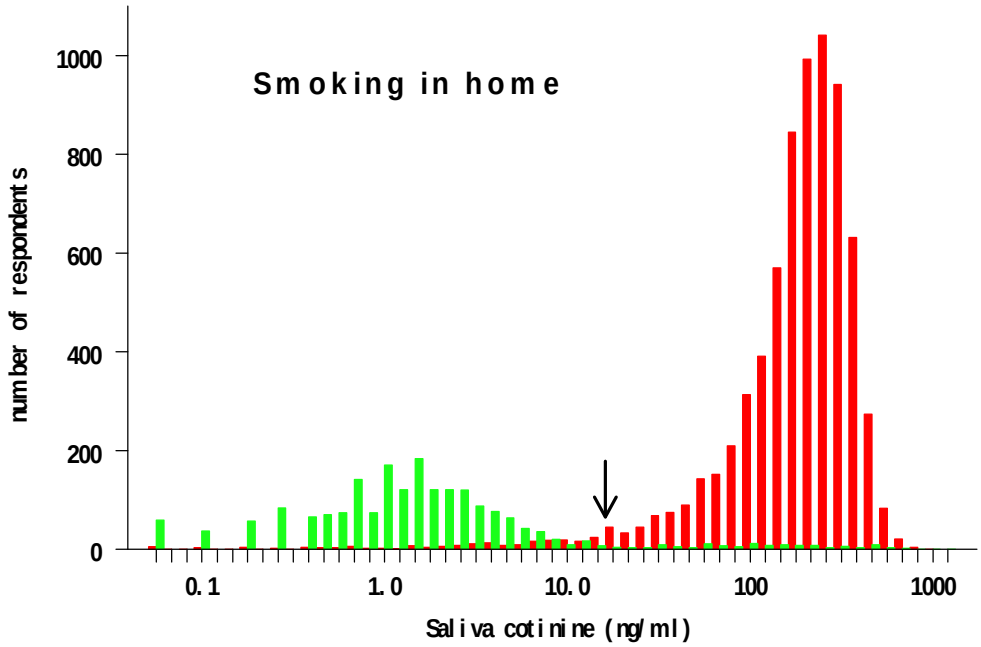
Figure 2

Distribution of saliva cotinine in non-smokers and smokers by presence (bottom) or absence (top) of smoking in the home.

Smokers (in red): self-reported cigarette smoking at initial interview and at nurse visit; non-smokers (in green): never regular smokers at initial interview + denial of smoking at nurse visit


Most affluent 0
1
2
Least affluent 3
number of respondents
Saliva cotinine (ng/ml)
0.1
1.0
10.0
100
1000


No smoking in home
number of respondents
3000
2500
2000
1500
1000
500
0
0.1
1.0
10.0
100
1000


Smoking in home
number of respondents
1000
800
600
400
200
0
0.1
1.0
10.0
100
1000
Saliva cotinine (ng/ml)