A study of serum thiocyanate concentrations in office workers as a means of validating smoking histories and assessing passive exposure to cigarette smoke

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ABSTRACT Patients in clinical practice often falsely report their smoking status. To see if this was so in occupational surveys we have validated smoking histories (using a serum thiocyanate assay) in 206 randomly sampled office workers who completed a smoking questionnaire administered by a doctor. Past and present cigarette consumption was determined with an assessment of exposure to passive cigarette smoke at home and at work in the non-smokers. Serum thiocyanate concentrations were measured by the ferric nitrate method. All smoking groups showed mean thiocyanate concentrations greater than non-smokers except those smoking five or fewer cigarettes a day. There was a significant increase in plasma thiocyanate with increasing smoking ($p < 0.01$). Non-smokers with and without exposure to passive smoke could not be separated by thiocyanate concentration. In our hands serum thiocyanate concentrations identified moderate and heavy smokers but could not distinguish between non-smokers, light smokers, and passive smokers. Fourteen non-smokers had serum thiocyanate concentrations higher than 70 $\mu\text{mol/l}$ which were still raised on a repeat sample. On a further questionnaire two admitted to smoking. To help confirm non-smoking status, expired carbon monoxide levels were also checked in this group. One person had a level of 22 ppm and subsequently admitted to smoking. In the others the levels were ≤ 10 ppm. Using a combination of serum thiocyanate assay and exhaled breath carbon monoxide levels, non-smoking was confirmed in 98% of those stating that they were non-smokers. In non-smokers exposure to passive cigarette smoke was much more likely to occur at work than at home.

Self reported smoking status may not always be the truth. This commonly occurs in those attending hospital clinics where a variety of pressures may account for smoking status being reported falsely by between 9% and 22% of patients.^{1,2} Not surprisingly, this problem is most pronounced in smoking withdrawal clinics where a falsification rate of 26% has been found.³ There have, however, been no studies validating smoking status in office worker populations where the workers have not actively sought medical attention.

There is also an increasing interest in the problems associated with work related exposure to passive cigarette smoke. Current evidence suggests that exposure to passive smoke is associated with many health problems well known to be linked with active smoking. Within the office setting the irritant effects of cigarette

smoke are an added problem. A simple indicator of exposure to passive smoke would therefore be useful.

Several different methods are available for assessing smoking status. Urinary nicotine and cotinine are sensitive indicators of cigarette smoke inhalation but have the problem of relatively short biological half lives of about two hours and 12-19 hours, respectively. Nicotine concentrations, though raised during unusually high exposure to passive smoke,⁴ are poor at distinguishing non-smokers who are passively exposed to cigarette smoke from those that are not.⁵ Cotinine has also been shown to be raised in non-smokers passively exposed to other people's cigarette smoke.⁶ Absolute changes are small, the analysis is expensive to perform and the relatively complicated method is currently under review.⁷ Cotinine is therefore of limited use in giving an overall view of cigarette exposure in the general population.

Serum thiocyanate was thought to have a much

longer biological half life of two weeks but recent evidence suggests it is probably closer to six days.⁸ Serum thiocyanate still has a theoretical advantage in giving a better long term view of smoking status and it has been suggested that thiocyanate may also be raised in people passively exposed to cigarette smoke. Most recently this was found to be the case in children,⁹ although the cause of some of the high concentrations found might be either dietary in origin or false reporting of true smoking status from the older children. The main confounding factor for serum thiocyanate estimations is from dietary sources.

The aim of the present study was to use serum thiocyanate estimations to validate a smoking history taken from office workers during a study of the symptoms of building sickness, to assess concentrations in the non-smokers who were passively exposed to the cigarette smoke of others, and to investigate confounding dietary factors in non-smokers with high serum thiocyanate concentrations.

Method

A total of 288 office workers were randomly sampled from two office buildings: 241 completed a smoking questionnaire administered by a doctor, of whom 206 (72%) consented to giving a blood sample. They were told that the blood sample was to determine antibodies to humidifier antigens in the building. The questionnaire included the Medical Research Council questions on past and present smoking habits. In addition an assessment of exposure to passive smoke was determined by asking non-smokers and ex-smokers "how many people with whom you live smoke regularly at home?" and "does anyone smoke in the office where you work?"

Serum thiocyanate concentrations were measured using the manual ferric nitrate method of Bowler.¹⁰ The recovery of the assay method was estimated, using added thiocyanate to routine serum samples. Average recovery was 94.8% with the range 89–102%. Interassay precision based on the method of difference of duplicates gave a coefficient of variation of 6.7%.

Questionnaire and serum thiocyanate were repeated in non-smokers who had an abnormally high serum thiocyanate concentration ($> 70 \mu\text{mol/l}$). Exhaled carbon monoxide levels were also measured in this group on two occasions, six months apart. The questionnaire included a repeat smoking history and an assessment of dietary sources of thiocyanate and its precursors. Expired carbon monoxide was measured using an "Eco-check" model EC 50 portable carbon monoxide analyser (PK Morgan Ltd). The analyser was initially zeroed then the calibration was checked using gas known to contain 50 ppm carbon

monoxide. Carbon monoxide was then measured in the end expired alveolar air after a 20 second breath hold.

Thiocyanate concentrations in the different smoking and non-smoking categories were compared using a one way analysis of variance.

Results

Of the 206 office workers sampled, only 51 admitted to being current smokers and 155 stated that they were either non-smokers or ex-smokers.

Figure 1 shows the serum thiocyanate concentrations found in non-smokers and smokers grouped for amount smoked. The overall difference between the groups was highly significant ($p < 0.01$). In the smokers the mean thiocyanate concentrations rose with increasing cigarette consumption. We found no significant difference between those smoking five cigarettes or fewer each day as compared with non-smokers. Figure 2 shows the non-smoking group classified into those who were passively exposed to cigarette smoke of others at home, at work, and both at home and at work, compared with non-smokers without exposure to passive smoke. There was no overall significant difference between the groups.

A serum thiocyanate of $70 \mu\text{mol/l}$ was used as the best discriminating concentration between non-smokers and smokers.¹¹ Using this criterion, 14 office workers who claimed to be non-smokers had raised concentrations. Questionnaires were repeated on 11 and on this occasion, two admitted to having been smoking at the time of the previous sample. Expired carbon monoxide measurements on the remaining nine showed one person with a level of 22 ppm who subsequently admitted to smoking. Mean expired carbon monoxide in the remaining eight who said they were non-smokers was 7 ppm ($\text{SD} \pm 2.4$). Table 1 shows the results of repeat blood samples taken from six of the remaining eight compared with a randomly sampled non-smoking control group. The concentrations remained significantly raised in the study group.

A dietary history asking about the consumption of various food stuffs believed to be high in thiocyanate precursors was obtained from both the study group and the control group (table 2). Overall there was no significant difference between the two groups. Pips from soft fruit and green bananas have high concentrations of thiocyanate precursors and may be responsible for the high thiocyanate concentrations found in these four people. Forty four per cent of the study group took vitamin tablets which, although not known to give rise to high thiocyanate concentrations themselves, may be indicative of the type of diet that these people consume.

Fig 1 Serum thiocyanate concentrations found in non-smokers and smokers grouped by daily consumption of manufactured cigarettes. "Other" includes pipe and cigar smokers and those who roll their own. Mean concentrations for each group are shown (continuous line) and one standard deviation (dotted line).

Fig 2 Serum thiocyanate concentrations in non-smokers with and without passive cigarette smoke exposure. Mean concentrations for each group are shown (continuous line) and one standard deviation (dotted line).

Table 1 Repeat serum thiocyanate estimations in non-smokers with levels higher than 70 $\mu\text{mol/l}$ compared with a randomly sampled non-smoking control group

	< 70 $\mu\text{mol/l}$		
	1st sample	2nd sample*	Control
No	6	6	10
Mean	103.5	84.3	39.6
SD	24.1	37.7	10.8

*Significance of difference compared with control group: $p < 0.01$.

Table 2 Comparison of consumption of foodstuffs containing thiocyanate precursors between non-smokers with high serum thiocyanate concentrations and a non-smoking control group

	Non-smokers	
	Thiocyanate (> 70 $\mu\text{mol/l}$)	Thiocyanate (< 70 $\mu\text{mol/l}$) (mean 37 $\mu\text{mol/l}$)
More than average consumption of:		
Brassicas	5	3
Pips	3	0
Radishes	1	1
Nuts	2	2
Green bananas	1	0
Kernels of soft fruit	0	0
Any of above	8/9	5/10
Vitamin preparations	4	0

Discussion

Only 25% of the office workers sampled admitted to smoking at the time of the survey and only five smoked more than 25 cigarettes a day. Thiocyanate estimations verified smoking in 73%. We found that serum thiocyanate concentrations could not differentiate non-smokers from smokers of fewer than six cigarettes daily. Previous workers have similarly found that misclassification of smokers tends to occur if they are light smokers.¹² Concentrations rose consistently with increasing cigarette consumption up to 25 cigarettes a day. Fourteen of the 155 (9%) non-smokers had thiocyanate concentrations in the smoking range which is comparable with previous studies.¹² On repeat questionnaire two workers admitted to having been smokers and to have smoked intermittently at the time of the first sample. Expired carbon monoxide showed a further smoker. Only three workers were therefore confirmed as having falsified their initially reported smoking status, thus showing that office workers, randomly sampled, are much less likely to mislead than other populations studied previously.¹² Non-smoking was validated in 97% of

those stating that they were non-smokers at the first interview. Vogt, using expired carbon monoxide and serum thiocyanate, found that when both measurements agreed, 99% of responses were correctly attributed.¹³

Serum thiocyanate remained persistently raised after being repeated in those non-smokers with concentrations higher than 70 $\mu\text{mol/l}$. This suggests that not all people found to have raised serum thiocyanate concentrations and who say that they are non-smokers can be deemed to be giving invalid replies. The most likely cause for the raised concentrations was thought to be dietary in origin.

Most non-smokers who were passively exposed to cigarette smoke had their exposure at work (58%) rather than at home (19%). Serum thiocyanate concentrations were not raised in those with passive cigarette exposure and are therefore not of use in assessing passive cigarette smoke inhalation in normal working environments.

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