RESEARCH PAPER

Tobacco smoking in Tanzania, East Africa: population based smoking prevalence using expired alveolar carbon monoxide as a validation tool

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Objectives: To describe the prevalence of tobacco smoking in an urban East African population while using a simple validation procedure to examine the degree of under reporting in men and women.

Design: A cross sectional population based study in adults (15 years and over) with sampling from a well maintained census register.

Setting: Ilala Ilala, a middle income district of Dar es Salaam, Tanzania.

Subjects: An age and sex stratified random sample of 973 men and women.

Main outcome measures: Self reported smoking status with correction by exhaled alveolar carbon monoxide (EACO).

Results: From the 605 participants (response rate 67.9%) age standardised (new world population) smoking prevalence, based on questionnaire and EACO, was 27.0% (95% confidence interval (CI) 20.8% to 33.2%) in males and 5.0% (95% CI 2.8% to 7.2%) in females. The age specific prevalence of smoking was highest in the age group 35-54 years (34.3%) for men and in the over 54 years group (16%) for women. Of those classified as smokers, 7.3% of men and 27.3% of women were reclassified as current smokers based on EACO (≥ 9 parts per million), after they had reported themselves to be an ex- or non-smoker in the questionnaire.

Conclusions: The data suggest: (1) high rates of smoking among men in an urban area of East Africa; and (2) the importance of validating self reports of smoking status, particularly among women.

There has been a dramatic increase in smoking in developing countries over the last 25 years.¹ It is estimated that by 2030 there will be 10 million deaths caused each year by tobacco, and if current smoking prevalence trends continue 70% of these deaths will be in developing countries.² The economic and public health effects will be substantial in countries that can least afford it.

However, in much of sub-Saharan Africa there are no validated comparable population based data available. In the "Tobacco control country profiles" prepared for the 11th World Conference on Tobacco or Health in 2000, information about tobacco use in Africa was described as "sparse" with data on smoking prevalence available only from "...scattered surveys in a few countries. Surveys of smoking behaviour, when available, usually only cover urban populations, selected regions, or specific population subgroups such as university students, occupational groups and hospital patients, and are rarely nationally representative."³ Smoking prevalence data were available from countries representing 92.3% of the world's population while in the World Health Organization's Africa region countries with smoking prevalence data represented only 55.3% of the population, by far the lowest proportion for any region.⁴

The available data suggest that the WHO Africa region has among the world's lowest smoking prevalence—about 36% for men and 9% for women in one estimate⁴ and 29% for men and 4% for women in another.⁵ Per capita consumption is also low. In 1995⁶ sub-Saharan Africa had the world's lowest number of cigarettes smoked per year by World Bank region—an estimated 700 cigarettes per adult in 1990-92 compared with 1200 per adult average in all developing countries.³

Trends in smoking prevalence and consumption in Africa are unclear. Consumption increased in seven selected African countries,⁷ by an estimated 50-174% between 1970-72 and 1990-92. Others argue that cigarette consumption is "not

growing particularly fast" in the African region, and give examples of declining cigarette sales in South Africa, Zimbabwe, Democratic Republic of Congo, and Ghana between 1990 and 1995.⁸

Most previous studies examining smoking prevalence in East Africa have focused on occupational or other selected groups such as hospital patients.⁹⁻¹¹ The few published population based studies from Africa show smoking prevalence to be much higher in men than women.¹²⁻¹⁶ However, under reporting of smoking habits may occur, particularly in women from cultures where social and economic constraints still exist.¹⁷ We are unaware of population based studies from Africa that have validated self reported smoking with biological markers such as exhaled alveolar carbon monoxide (EACO) or urinary cotinine.

The primary objective of this study is to describe the age and sex specific prevalence of tobacco smoking while measuring EACO to test the degree of under reporting in men and women in an urban area of Tanzania. We also investigated cigarette consumption, age of starting to smoke, and reasons for quitting.

SUBJECTS AND METHODS

Subjects and setting

The survey was carried out in November 1998 in Ilala Ilala, a ward in a middle income urban area of Dar es Salaam, Tanzania's largest city. Most of the population are employed in semi-skilled jobs and live in closely sited single storey buildings made from mud or brick. Most buildings house up to six family groups who share cooking and washing areas.

An age stratified sample of 973 adults resident in Ilala Ilala (representing 9.9% of this area's population) was randomly selected from a recent census register of the Adult Morbidity and Mortality Project (AMMP).¹⁸ The census is undertaken

Table 1 Age and sex characteristics of the sample after adjustment for migration and death, and study population

	Males	Females	Total
Sample (n)	468	423	891
Response	286 (61.2%)	319 (75.4%)	605 (67.9%)
Response by age groups			
15–34 years	102 (64.2%)	110 (71.4%)	
35–54 years	99 (55.6%)	103 (76.9%)	
55+ years	85 (64.9%)	106 (78.5%)	
Study participants			
Mean (SD) age (years)	42.7 (18.1)	43.9 (18.1)	42.9 (17.5)
Age range	15–94	15–98	15–98

every six months as part of an ongoing demographic surveillance system. Based on data from AMMP and our experience in a previous survey,¹⁹ we estimated that this sample would give us 600 (300 men and 300 women) subjects after allowing for anticipated non-response caused by migration, refusal or death. We anticipated the main reason for non-response would be failure to contact potential subjects as a result of migration within Dar es Salaam or to other areas of Tanzania. Within the constraints of the resources available, the sample size was chosen to provide reasonably precise overall estimates of smoking prevalence by sex. For example, assuming a 20% prevalence in a group of 300 the 95% confidence intervals (CI) would be 15.5% to 24.5%, and with a prevalence of 5%, 95% CI 2.5% to 7.5%. We stratified the sample by the following age groups: 15–34, 35–54, 55 years or older. We aimed to recruit 100 per age and sex group.

Methods and materials

We employed a pre-piloted structured questionnaire to collect information on smoking patterns, domestic environment, and respiratory symptoms. Questions were based on three validated questionnaires. The section that examined smoking habits was taken from the Tasmanian Smoking Survey.²⁰ The questionnaire was translated into Kiswahili with back translation to English and revision where necessary to ensure direct translation was achieved. Appropriately trained local field workers carried out an interview based on the questionnaire in the subjects' home.

We made strenuous efforts to include all individuals. Subjects were classified as non-responders if they were not present when visited at their home on three separate occasions at different times of the day on different days during the week. If a subject was too frail or sick to participate, their next of kin gave responses in their presence.

We measured EACO using a Bedfont Smokerlyzer EC50 (Bedfont Scientific, Upchurch, UK) as per manufacturers instructions. This was calibrated four times per week using standard calibration gas (50 parts per million (ppm)).

Current smokers were defined as subjects who gave a positive reply to both of the questions "Have you ever smoked regularly?" and "Do you currently smoke?". "Regularly" and "current" were defined as "at least one cigarette a day". We also classified subjects as a current smoker if they had a positive EACO measurement (≥ 9 ppm) regardless of their self reported smoking status. Ex-smokers were defined as those who replied positively to the question "Have you ever smoked regularly?", negatively to the question "Do you currently smoke?", and had an EACO of < 9 ppm. Non-smokers replied negatively to both the questions "Have you ever smoked regularly?" and "Do you currently smoke?", and had a negative EACO measurement. Participants who refused to perform the EACO test were classified by their self reported smoking status only.

In order to investigate potential confounding from exposure to cooking fuels on EACO levels, we asked women about their exposure to cooking fuel in the house. Those using charcoal,

Table 2 Crude and age standardised prevalence rates of current and ex-smoking by age and sex

	Current smoker*		Ex-smoker†		Non-smoker‡	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Female						
15–34 years	2	1.8 (0.2 to 6.4)	0	0.0 (0.0 to 3.3)	108	98.1 (93.6 to 99.8)
35–54 years	3	2.9 (0.6 to 8.3)	5	4.9 (1.6 to 11.0)	95	92.2 (85.3 to 96.6)
55+ years	17	16.0 (9.1 to 23.0)	24	22.6 (14.7 to 30.6)	65	61.3 (52.0 to 70.6)
Total	22	6.9 (4.4 to 10.3)	29	9.1 (6.2 to 12.8)	268	84.0 (80.0 to 88.0)
Age adjusted§		5.0 (2.8 to 7.2)		6.2 (3.9 to 8.5)		
Age adjusted¶		3.0 (1.0 to 5.0)		2.7 (1.6 to 3.8)		
Male						
15–34 years	22	21.6 (13.6 to 29.6)	8	7.8 (3.5 to 14.9)	72	70.6 (61.7 to 79.4)
35–54 years	34	34.3 (25.1 to 44.6)	24	24.2 (16.2 to 33.9)	41	41.4 (31.6 to 51.8)
55+ years	26	30.6 (21.1 to 41.5)	23	27.1 (18.0 to 37.8)	36	42.4 (31.7 to 53.6)
Total	82	28.7 (23.4 to 33.9)	55	19.2 (14.7 to 23.8)	149	52.1 (46.3 to 57.9)
Age adjusted§		27.0 (20.8 to 33.2)		16.1 (11.6 to 20.6)		
Age adjusted¶		26.2 (19.6 to 32.8)		14.4 (9.9 to 18.9)		

%, of sex/age group.

*Subjects who currently smoke more than one cigarette daily and had an EACO reading of >9 ppm.

†Subjects who have smoked more than one cigarette daily but no longer does and had an EACO reading of <9 ppm.

‡Subjects who deny ever smoking more than one cigarette daily and had an EACO reading of <9 ppm.

§Directly age standardised prevalence (new world population).

¶Directly age standardised prevalence (Ilala Ilala population structure).

Table 3 Characteristics of smoking habits

	Male	Female
Smoking classification (% of current smokers/sex group (n))		
Quest +ve & CO +ve	63.4 (52)	40.9 (9)
Quest +ve & CO -ve	29.3 (24)	31.8 (7)
Quest -ve & CO +ve	7.3 (6)	27.3 (6)
Mean (SD) age started smoking		
15–34 years	18.6 (5.10)	22.5 (0.71)
35–54 years	22.8 (6.15)	21.5 (4.46)
55+ years	22.8 (7.85)	22.7 (5.34)
Total	21.9 (6.8)	22.6 (5.09)
Median (range)* number smoked per day (current smokers)	n=74	n=15
15–34 years	6 (1–20)	1 (–)
35–54 years	8 (2–30)	5 (–)
55+ yrs	5 (2–40)	3 (1–20)
Total	6 (1–40)	3 (1–20)
Median (range)* years smoked (current smokers)	n=79	n=19
15–34 years	4 (1–17)	1.5 (1–2)
35–54 years	19 (2–39)	20 (–)
55+ years	40 (11–63)	39.5 (29–65)
Total	20 (1–63)	39 (1–65)
Pack years*		
Ex-smokers median (range)	n=53	n=31
15–34 years	0.15 (0.004–9)	0 (–)
35–54 years	0.83 (0.1–28)	0.9 (0.001–5)
55+ years	12.4 (0.6–90)	1.68 (0.1–40)
Total	5.0 (0.004–90)	1.6 (0.001–40)
Median (range) current smokers	n=71	n=15
15–34 years	1 (0.1–6)	<1 (–)
35–54 years	7 (0.3–39)	5 (–)
55+ years	9.6 (1.1–126)	5 (2.8–45)
Total	6.48 (0.00–126)	5.0 (0–45)
Reasons for quitting (% of ex-smoker/sex group (n))	n= 55	n=29
Current health problems	21.8 (12)	34.5 (10)
Potential health problems	40.0 (22)	38.0 (11)
Financial reasons	5.5 (3)	6.9 (2)
Family pressure	7.3 (4)	10.3 (3)
Other	25.5 (14)	10.3 (3)

*Where no range is given, n = 1.

gas, kerosene or wood more than five times in one week were assigned to a “high exposure” group. Pilot studies and information from local colleagues indicated that very few men were involved with the process of cooking.

Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS version 7.5.1) Confidence intervals were calculated using the CIA package (Version 2.0.0). χ^2 tests and analysis of variance were used as appropriate. Directly aged standardised rates were calculated using the age structure of Ilala Ilala from the census file and the new world population.²¹

RESULTS

Six hundred and five subjects, from the 973 sampled, agreed to enter the study. After adjusting for subjects known to have migrated or died (8.4% of sample) since the last census, the response rate was 67.9%. Response was lower for males than for females (M ν F: 61.2% ν 75.4%, 95% CI for difference 8.3% to 20.3%) The age and sex characteristics of the population studied are shown in table 1. EACO was measured on 94.9% of the participating subjects. The remaining 5.1% (M ν F: 4.2% ν

Table 4 Mean (SD) expired alveolar carbon monoxide in women by cooking exposure level and smoking status

Smoking status	Cooking exposure level	
	Low*	High†
Not a current smoker‡	2.73 (1.67)	2.28 (2.22)
Current smoker§	9.17 (4.71)	11.10 (10.9)

*Exposure to wood, charcoal, kerosene or gas while cooking less than 5 times per week. †Exposure to wood, charcoal, kerosene or gas while cooking more than 5 times per week. ‡Any women who denied currently smoking on questionnaire. §Any women who admitted to be currently smoking on questionnaire.

6.0%) either refused or were unable to master the technique required for a satisfactory reading.

The smoking behaviour of males and females subdivided by age group is shown in table 2. Crude smoking prevalence was 28.7% (95% CI 23.4% to 33.9%) in men and 6.9% (95% CI 4.4% to 10.3%) in women. The age adjusted rate (directly standardised to the new world population) was 27.0% (95% CI 20.8% to 33.2%) in males and 5.0% (95% CI 2.8% to 7.2%) in females, and was 26.2% (95% CI 19.6% to 32.8%) in men and 3% (95% CI 1.0% to 5.0%) in women when standardised to the Ilala population structure. The age specific prevalence of smoking in men was highest in the age group 35–54 years but highest in women in the over 54 years group. Very few women under the age of 35 years smoked.

If self reported non-smokers, who refused or could not perform the EACO test, were assumed to have a smoking prevalence equal to or twice that of all men or women included in the survey who completed EACO tests, crude prevalence of smoking changed to 29.7% and 31.1% in men and 7.2% and 8.2% in women.

Most current smokers were identified from their responses in the questionnaire, yet table 3 shows that 7.3% (95% CI 2.7% to 15.3%) of male smokers and 27.3% (95% CI 10.7% to 50.2%) of female smokers were classified as current smokers based on EACO levels alone. The proportion of women defined as current smokers in this way was significantly greater than for men (χ^2 test, $p = 0.009$).

Additional details about smoking habits are shown in table 3. The mean age of starting smoking was between 21–23 years, and similar for men and women (95% CI for mean difference 1.4 to 2.8 years), although the age range for men starting smoking was broader than for women. Most smokers had low lifetime cigarette consumption, mainly because of a low numbers of cigarettes smoked per day. The median pack years smoked among current smokers was not significantly different between males (6.48 pack years) and females (5.0 pack years), median difference 0.3 (95% CI for difference –2.9 to 3.2). Male ex-smokers did have higher values for pack years smoking (5.0 ν 1.7 for females, median difference 1.75 pack years, 95% CI for difference 0 to 7.9). Current or potential health problems was the most common reason given for stopping smoking (65.5% of ex-smokers). Other reasons given for stopping smoking included religious beliefs and lack of perceived benefit from smoking.

We investigated whether women with heavy exposure to smoke from cooking fuels had been misclassified as smokers. For this analysis non-smokers were categorised as all subjects who denied currently smoking and therefore included ex-smokers. “Smokers” were those people who admitted currently smoking on questionnaire. Table 4 shows mean EACO in high and low cooking smoke exposure groups. Women with high domestic smoke exposure were no more likely to have a raised exhaled carbon monoxide than those with low exposure (χ^2 test, $p = 0.65$). An analysis of variance (ANOVA) test was used to determine if there was a significant relation

between cooking exposure and EACO level independent of smoking status. The two were shown to be independent. As expected, smoking exercised a dominant effect on the level of EACO ($p \leq 0.0001$) whereas the level of cooking exposure was not significantly related to EACO levels ($p = 0.07$). There was therefore no evidence to support the suggestion that the “female current smokers”, who denied smoking yet had positive CO measurements, were being misclassified because of exposure to CO from domestic exposures such as cooking.

DISCUSSION

This study found that smoking is more common in Tanzanian men than women in a middle income area of Dar es Salaam. The prevalence of tobacco smoking is 27% in males and 5% in females after direct standardisation to the new world population. These findings are similar to the WHO estimated smoking prevalence in Africa⁶ and other areas of Africa where population based studies have been carried out.¹⁴

We believe the results provide a good estimate of smoking prevalence in this population. The strengths of this study include the use of a well maintained census register as the basis for a random stratified sample and the use of validated and standardised questions to assess smoking behaviour. This allows for comparison with results from other populations. We also validated self reported smoking with a biochemical marker. To our knowledge this is the first population based study to use EACO to validate self reported smoking in sub-Saharan Africa.

The study has some limitations. The survey occurred over a period of one month. The young men in particular in this community often work away from home or for very long hours. This was reflected in the low response rate (55.6 %) in males within the 35–54 years age group and may reduce the validity of the finding in this group. Future studies should take place over longer period of time to allow for seasonal working and travel trends. However, the high female response rate combined with the validation of self reported smoking using EACO should ensure we obtained a robust estimate of female smoking prevalence for this population. Another weakness was that in subgroup analyses the sample sizes were relatively small and the confidence intervals therefore are often wide. The point estimates need to be interpreted in this light. Finally, we only investigated tobacco use through cigarettes. Although we are not aware of the use of other forms of tobacco in this population, tobacco chewing is common in other African countries.⁹

A previous study in Tanzania from 1987–89, which used data collected using a combination of self reported and proxy reported smoking by heads of households, showed a lower prevalence of tobacco smoking in men in Dar es Salaam (20.9%) but similar in women (3.8%).¹⁸ Other studies found similar rates of smoking in women (2–4%) in three rural areas of Tanzania, but a much more variable prevalence in men (43% in Kilimanjaro, 28% in Morogoro, and 8.6% in Mara).¹² This suggests that smoking prevalence is increasing among men in Dar es Salaam, but not among women. The finding of very low lifetime consumption of tobacco in pack years may reflect the economic status of the people in this area of Tanzania.

The results of this study have implications for future surveys of tobacco use in similar populations. We illustrated how questionnaire data can underestimate smoking prevalence when used as the only assessment tool, particularly among women. When prevalence is low, as in this female population, the absolute impact of denial of smoking may be modest. However, as prevalence increases, the underestimate of “true” smoking prevalence could be substantial. Under reporting of smoking will vary with local attitudes and beliefs. Hence, valid international and intercultural comparisons of smoking prevalence, particularly among women, require self reported results to be validated by biochemical methods.

What this paper adds

There has been a dramatic increase in smoking in developing countries over the last 25 years. However, in much of sub-Saharan Africa there are no validated comparable population based data available and we are not aware of any population based surveys incorporating biochemical validation of smoking status from any African region. Under reporting of smoking habits may occur, particularly in women from cultures where social and economic constraints still exist. We aim to describe the prevalence of tobacco smoking in an urban area of Tanzania and explore the use of exhaled alveolar carbon monoxide for biochemical validation.

This study confirms that smoking is much more common in men than women in this population. Without biochemical validation of self reported smoking, smoking prevalence may be underestimated, particularly among women. Exhaled alveolar carbon monoxide is a practical and effective method for biochemical validation of smoking prevalence surveys in developing countries.

Urinary, salivary or serum cotinine are often viewed as the “gold standard” for detecting and measuring cigarette consumption. In comparison, EACO has a shorter half life of 2–5 hours and may be affected by other environmental sources of carbon monoxide such as passive smoking or road traffic.^{22–23} Hence, it is less sensitive and specific, particularly in detecting light smokers or smokers who have not had a cigarette for several hours. Most authors, however, have concluded that EACO is a useful test. Evaluations of EACO in a variety of settings and contexts^{24–31} have mostly assessed sensitivity and specificity in relation to self reported smoking status. Comparisons with serum or salivary thiocyanate have generally found higher specificity and sensitivity for EACO,^{25–27–32} while comparisons with serum cotinine have shown EACO performs as well^{27–29} or nearly as well.²⁸ Furthermore, EACO has some clear advantages as a survey marker, particularly in countries which are poor in resources. It is inexpensive, simple, portable, and non-invasive and therefore likely to be a generally acceptable method across different cultures. It also gives instant results and does not require the kind of laboratory assistance that is extremely difficult to arrange in many developing countries.^{27–33–34}

The sensitivity and specificity of EACO varies with the population, setting, and cut off point chosen. Studies investigating the best cut off point have suggested concentrations of 6 ppm,²⁷ 8 ppm,²⁸ and 9 ppm³² to minimise false negatives and false positives. We chose a cut off point of 9 ppm to achieve a reasonable sensitivity while maximising specificity. We are confident that self reported non-smokers with raised EACO were smokers, though we acknowledge that because of the high cut off point some deceivers (particularly light and irregular smokers) will have been missed. The lack of sensitivity of EACO at this cut off point in a population with a high proportion of light smokers is demonstrated by the finding that about 30% of self reported smokers had an EACO of < 9 ppm. However, we believe that using the combination of self reported smoking status and changing the status only for questionnaire negative, EACO positive subjects is a reasonable approach to measuring smoking prevalence in surveys like this.

The low prevalence of smoking in women found in this study should not encourage complacency. There is substantial evidence of aggressive tobacco marketing in Tanzania. The tobacco companies are increasing their targeting of women in developing countries³⁵ at a time when many cultural prohibitions on women are easing with the effects of globalisation, making these women a high risk population for increases in smoking prevalence.^{36–37}

The main reasons for quitting smoking given by ex-smokers were health related. Other studies in Africa have shown similar results to ours.³⁸⁻³⁹ This contradicts the view that in many developing countries knowledge of the health effects of tobacco is poor.¹⁻⁴⁰ However, the information obtained by our survey about knowledge and attitudes to smoking was fairly superficial, and more in-depth research is needed to explore understanding of the level and extent of the health risks associated with smoking, and the impact of that knowledge on behaviour.

The WHO's Tobacco Free Initiative⁴¹ and the World Bank⁴² have urged countries to develop comprehensive tobacco control strategies. A key requirement for the development and monitoring of such strategies is valid population based smoking prevalence data. Without this, tobacco control is unlikely to be effective. We have shown that without biochemical validation of self reported smoking, smoking prevalence may be underestimated, particularly among women. Validation with a biochemical marker is imperative in order to achieve true smoking prevalence. Based on our experience we believe EACO is a cheap, simple but effective tool to validate self reported smoking prevalence in prevalence surveys in sub-Saharan Africa.

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