Science Journal of Applied Mathematics and Statistics
2014; 2(3): 60-65
Published online June 20, 2014 (http://www.sciencepublishinggroup.com/j/sjams)
doi: 10.11648/j.sjams.20140203.11

Assessing public awareness about the health effects of nicotine and cigarettes using negative binomial regression

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To cite this article:
Awoke Seyoum Tegegne. Assessing Public Awareness about the Health Effects of Nicotine and Cigarettes Using Negative Binomial Regression. *Science Journal of Applied Mathematics and Statistics*. Vol. 2, No. 3, 2014, pp. 60-65. doi: 10.11648/j.sjams.20140203.11

Abstract: Both the public and private sectors have acted responsibly to help decrease smoking-related deaths by putting health warnings on all cigarette packages. This study investigated the social or demographic factors associated with public awareness of health warnings on the harmful effects of environmental tobacco smoke based on baseline data collected by the health bureau of Amhara Region (in Ethiopia). Respondents in the survey were asked to recall the number of anti-smoking messages which appeared as warning messages on cigarette advertisements. The number of anti-smoking messages recalled ranged from 0 to 7 with a mean of 2.90 (variance of 3.11) and a median of 3.00. Because the variance (3.11) was different from mean (2.9), the negative binomial regression model provided an improved fit to the data and accounted better for over dispersion than the Poisson regression model, which assumed that the mean and variance are the same. The level of education was found to be the most significant factors. Moreover, the lower income socio-economic class nonsmokers' anti-smoking messages recalling rate was 2.5 times that of the lower socio-economic class smokers. Unlike men, women's anti-smoking message response rate increased with income.

Keywords: Environmental Tobacco Smoke, Negative Binomial Regression, Over Dispersion, Poisson Regression, Rate Ratios, Smoking

1. Introduction

Cigarette smoke is a complex mixture of chemicals produced by the burning of tobacco and additives. The smoke contains compounds of different physicochemical natures and degrees of harmfulness. Some of these compounds cause heart and lung diseases, and all of them can be deadly[7]. The cause distribution of mortality due to smoking in Ethiopia is similar to that found in developing countries, such as China and India, with the exception of respiratory conditions[14]. According to USAID survey study conducted in 2007, in terms of the overall deaths in Ethiopia, estimated that about 8.5% of all deaths could be attributed to smoking. Accordingly, smoking ranked third (after unsafe sex/ sexually transmitted diseases and high blood pressure) in terms of mortality among 17 risk factors evaluated. Sitas et al. (2004) also estimated that about 8% of all adult deaths (> 15 yrs) were caused by smoking in 1998.

Environmental tobacco smoke, also known as passive smoking or second hand smoke occurs when non-smokers inhale other people's tobacco smoke. This includes mainstream smoke (i.e. smoke that is inhaled and then exhaled into the air by smokers) and side stream smoke (i.e. smoke that comes directly from the burning tobacco in cigarettes). Environmental tobacco smoke contains the same harmful chemicals as the smoke that smokers inhale. Recently, the documented adverse effect of tobacco smoke components on so called passive smokers has been very strongly emphasised[6, 16]. Repace[17], there is strong evidence that environmental tobacco smoke causes serious damage to human health. Several epidemiological investigations[4]; Environmental Protection Agency[13,18,21], National Cancer Institute, 2007 has demonstrated that environmental tobacco smoke contributes to the following health effects: carcinogenic (lung and nasal sinus cancer), cardiovascular (heart disease mortality, acute and chronic coronary heart disease morbidity), respiratory (in children: acute lower respiratory tract infections, asthma induction and

exacerbation, chronic respiratory symptoms, middle ear infections; in adults: eye and nasal irritation), and developmental (foetal growth: low birth weight or small for gestational age, sudden infant death syndrome). The effects associated with environmental tobacco smoking exposure include cervical cancer, exacerbation of cystic fibrosis, decreased pulmonary function, spontaneous abortion and an adverse impact on cognition and behavior[22]. Bearing all this in mind, all possible aspects of passive tobacco smoke as well as actions aimed at reducing related effects have been markedly intensified during recent years. Both the public and private sectors have acted to help decrease smoking-related deaths and illnesses in Ethiopia. Since 1993, health warnings have been required on all cigarette packages. Parliament banned cigarette advertising on TV and radio in 1999. The Tobacco Control Act of 1993 restricts smoking in certain public places. These regulations range from simple restrictions, such as designated areas in government buildings, to laws that ban smoking in all public places and workplaces. Taxes on cigarettes have risen in recent years to discourage young people from starting to smoke and to encourage smokers to quit[22].Though there has been growing concern by government and non-government organisations about potential adverse health effects related to exposure to environmental tobacco smoke, public awareness is not high when compared to other health problems (like malaria, HIV/AIDs and tuberculosis). Brundtland (2000), Director General of the World Health Organization (WHO), noted that by 2030, unless the world takes preventative measures, tobacco will kill more people than malaria, tuberculosis and maternal and childhood conditions combined. Appropriate awareness assessment is crucial, since the health effects of environmental tobacco smoke are likely to be perceived as small in magnitude.

Appropriate awareness assessment is also needed for inferring causality and for risk assessment. In addition, exposure assessment is obviously necessary for the development of preventive measures. The purpose of this study was to assess people's awareness of health warnings regarding the harmful effects of smoking in Ethiopia using some statistical models (negative Binomial regression model). This was done by considering some of the important discrete probability distributions such Poisson , Binomial ,negative binomial probability distributions and comparing their relevancy with the nature of data ,negative binomial was selected to know the nature of distribution of harmful effects of smoking. In particular, the investigator investigated which social or demographic groups are more aware of governmental and none-governmental health warnings on the harmful effects of environmental tobacco smoke. Such a study provides a first step to epidemiologists, health-related field specialists and public well-being advocators for appropriate intervention for a targeted group of people. Such a targeted approach is absolutely essential in a society like Ethiopia where there is immense socio-demographic disparity.

2. Materials and Methods

Ethiopian adults' perceptions of the health effects of nicotine and cigarettes were surveyed by means of a series of interviewer-administered questionnaires conducted by fieldworkers of the Health Bureau of Amhara Region through surveys in October, 2007. The Amharan population (North West Ethiopia), one of the 11 regions in Ethiopia with approximately above 20,000,000 people with three types of language speakers such as Amharic, Oromogna and Agewegna speakers) was again classified by 11 zones whose names are West Gojjam, East Gojjam, Awi, Bahir Dar special zone, North Gondar, South Gondar, North Shewa, South Wello, North Wello, Aromia and Waghimira zones, based on Language and geographical location. The sample allocation to the resulting strata was done proportionally (to the target population in each strata here in this case zones are consider as strata) the 2007 census figures. Multistage cluster sampling with probability proportional to size was used to draw respondents, with the adjusted 2007 population census figures as a measure of size. Census enumeration areas and similar areas were used as the clusters. There were 11 clusters/zones in the region and the clusters that constituted in the data were considered to be a random selection of clusters from all the clusters in the region. A random selection of respondents was then drawn from the clusters, for example, there were 87 respondents from cluster 1. All clusters were drawn with a probability proportional to size, whilst households were drawn from the final clusters with equal probability. One respondent whose aged is 15 years or older was selected from each household by applying a grid. For each selected respondent, a sampling weight was calculated, using the stratification variables of province and type of area and by post-stratification for age, gender, and education. Respondents in the survey were asked to recall a number of anti-smoking messages which appeared as warning messages on cigarette advertisements in different message transmission methods. The sample size of 500 was chosen by the health bureau of the region surveyors. The surveyed variables were, sex, marital status, socio-economic status, smoking status, age and education level. Using a census enumeration frame, a random sample of 500 respondents was drawn from the selected clusters. Respondents in the survey were asked to recall the number of anti-smoking messages which appeared as warning messages on cigarette advertisements. The following were different warning messages on Ethiopian cigarette packages, and advertisements shown on radio, television, cinemas, newspapers, magazines, billboards, posters in shops and pamphlets. For each respondent the total number of messages spontaneously recalled was noted. The socio-demographic variables categories were encoded as sex (male and female), age (< 25 yrs, 25–54 yrs and 55+ yrs), socio-economic status (lower income, middle income and upper income), marital status (Coupled, singled or divorced), smoking (non-smoker or smoker), and

educational level on a 4-point scale (primary schools, secondary schools, senior secondary schools and Tertiary or University levels).In other words, the survey only concentrated on respondents' current smoking status.

A generalised linear model (GLM) analysis was carried out to investigate this secondary data collected by health bureau of Amhara region (demographic and socio-economic factors affecting respondents' awareness of health warnings on the harmful effects of smoking). Since the response variable of interest, which is the total number of messages spontaneously recalled, was a count data or discrete data, it may not be reasonable to assume that the data were normally distributed. As a result the traditional linear model is not applicable. A GLM extends the traditional linear model to a wider range of data analysis problems and a function can be used to link the expected response mean and a linear function of the explanatory variables. In short, a GLM can be constructed by choosing an appropriate link function and response probability distribution[19, 20,2] .

The best known GLMs for count responses assume a Poisson or a negative binomial distribution. The Poisson distribution has a positive mean which equivalent to its variance. Although a GLM can model a positive mean using identity link, it is more common to model the log of the mean. The log link is particularly attractive for a Poisson or a negative binomial regression because it ensures that all the predicted values of the response variable will be nonnegative. A random Variable X which has negative Binomial distribution has its probability Mass function is written as

NB(x, K, p) = $\binom{x-1}{k-1} p^k q^{x-k}$, for x= k, k+1, k+2, Where P and k are parameters and k, k+1, k+2…are successive terms of binomial expansion. As it is known, the mean and variance of this discrete probability distribution are not necessarily equal to each other and this distribution sometimes said to be binomial waiting time or Pascal distribution.

On the other hand detailed discussion about Poisson GLMs can be found in Lindsey (1995) and Agresti (2002). The Poisson regression restricts the response variable to have mean-variance equality. If this assumption is violated, the resulting estimates are consistent, but, estimates of the variance are not. It can result in spuriously small standard errors of the estimates (Barron, 1992). These inconsistent variance estimates invalidate any hypothesis testing.

Either the deviance or Pearson Chi-square divided by the degree of freedom is used to detect over dispersion or under dispersion in the Poisson regression (SAS Institute, 2004). Values greater than 1 indicate over dispersion, that is, the true variance is greater than the mean, whereas values smaller than 1 indicate under dispersion, that is, the true variance is smaller than the mean. Evidence of under dispersion or over dispersion indicates inadequate fit of the Poisson model. Over dispersion can be tested by a likelihood ratio test based on the Poisson and negative binomial distributions. This test tests equality of the mean and the variance imposed by the Poisson distribution against the alternative that the variance exceeds the mean[9]. The usual method of controlling for over dispersion involves correcting the standard errors and test statistics [2]. Although this adjustment is an improvement over a conventional Poisson regression, the coefficients lack efficiency because they have more sampling variability than its necessary[1].An alternative strategy for analysing count data, which avoids the problems inherent with the Poisson regression over dispersion or under dispersion, is to fit a negative binomial regression model[1,2]. All the analyses of this study were carried out using SPSS version 20.

3. Results

3.1. Descriptive Results

Table 1. *Descriptive results of the number of anti-smoking messages recalled (Mean Median Mode STD Deviation)*

Variables	Mean	Median	Mode	Std deviation
Gender				
Male	2.33	2.00	1.00	1.24
Female	3.7	3.00	5.00	2.01
Age				
< 25 years	2.9	3.00	1.00	1.77
[25-55] years	2.88	3.00	1.00	1.77
(55, +) years	2.89	3.00	1.00	1.77
Socio-economic status				
Low income	2.74	1.5	1.00	1.97
Middle income	1.06	3.00	1.00	1.93
Upper income	3.77	5.00	2.00	1.93
Marital Status				
Couple	3.1	3.00	3.00	1.95
Single	2.5	2.00	1.00	1.6
Divorced	3.00	3.00	3.00	3.1
Smoking status				
Smoker	2.5	2.00	1.00	2.7
None- Smoker	3.4	3.00	5.00	1.76
Education				
Primary	1.00	1.00	1.00	0
Secondary	5.38	6.00	6.00	1.34
Senior Secondary School	3.00	3.00	5.00	1.5
Tertiary level	2.89	3.00	3.00	1.75

The sample consisted of 57.2% men and 42.8% women. The respondents ranged in age from 15 to over 55 years. Most of them were coupled (43.6%). The highest attained level of education was tertiary or university (47.4%). The lowest level of education was primary level education (9.6%). About 57% of the respondents were active smokers; and the remaining 43% were non-smokers. In terms of socio-economic status, 23.8% of the respondents were from higher income, 47.4% from middle income and the remaining 28.8% were from lower income groups. Also the age ranges of the respondents were less than 25 years

(19.2%), 25 to 55 yrs (72.4%) and over 55 years (9.2%). The number of anti-smoking messages recalled ranged from 0 to 7 with a mean of 2.9 (variance of 3.11), and a median of 3.00. The distribution of the number of messages recalled is skewed to the right. In other words, few respondents recalled five or more messages. The modal number of messages recalled was one message (28.7%) followed by three messages (24%).

The descriptive results from the survey are presented in Table 1. Males have a slightly higher mean number of messages recalled. The younger respondents (< 25 yrs) and the older respondents have the higher mean number of messages recalled when compared to the middle age group [25 ,55] years who have a lower mean number of messages recalled. The socio-economic group reveals that higher incomes have highest mean number of messages recalled, 3.77. Those coupled groups have a higher mean number of messages recalled as compared to the other two groups (single group and divorced group). The nonsmoker groups have highest mean number of recalled as compared to smoker groups. The level of education shows us secondary school groups have highest mean number of recalled as compared to the other three groups (Primary levels, senior levels, secondary and tertiary levels).

3.2. Statistical Model Results

Turning first to the main effects model, Table 2 shows the results of the Poisson regression fit statistic in explaining the number of anti-smoking messages recalled.

Table 2. *Goodness of fit statistic for main effects Poisson and negative binomial regression*

Criteria	Estimate	Poison Model	Negative Model
Deviance	Value	907.62	550.60
	D.F	486	486
	Value/D.F	1.87	1.13
	Value	885.52	507.03
	D.F	486	486
	Value/D.F	1.82	1.04
Log-Likelihood	Value	208.703	254.64

For the Poisson model the Pearson Chi-square values and deviance divided by the degrees of freedom are significantly larger than 1. But for the negative binomial model, both the Person Chi-square and deviance ratios are sufficiently close to 1, indicating that the negative binomial model fits the data well, whereas the Poisson model does not.The formal test for significance of over dispersion, the log-likelihood ratio, which is –2 × (log-likelihood of Poisson regression –log-likelihood of negative binomial regression), is computed. The log-likelihood ratio becomes 63.03, which corresponds to a p-value < 0.00001, giving evidence of over dispersion. Evidence of over dispersion indicates inadequate fit of the Poisson model. A common correction is to estimate the event count using negative binomial regression, which is a generalisation of the Poisson model. In the analyses discussed below, the negative binomial specification is used. It is reasonable to assess the magnitude of the effect of several factors acting jointly over and above their effects considered separately. In other words, the extent to which the effect of one factor changes for different values of one or more other factors needs to be measured, this is called the interactions effect. The significance of the interactions effects were looked at by adding them into the main effects model one at a time and retaining the significant interactions. Accordingly, all the three-way and higher-level interactions effects were obtained non-significant. From the two-way interactions only socio-economic status and smoking, and socio-economic status and sex were significant. The interaction plots were also used to assess the effect a pair of factors has on the response by plotting, for each value of one of the factors, a line between the mean response at the low level of the other factor to the mean response at the high level. An interaction effect is indicated when the lines for different levels of the first factor have unequal slopes. They were presence of interactions between socio-economic status, smoking, and socio-economic status and sex. For the smoking category the mean number of messages recalled increases as their socio-economic status increases from the lower to the upper class. But for the non-smoker category the mean number of messages recalled decreases as their socio-economic status increases from lower to middle class while the mean number of messages recalled increases as their socio-economic status increases from middle to upper class. The analysis also indicates that there is a decrease in the mean number of messages recalled from the males to the females in each of the socio-economic status classes, namely, upper, middle and lower.

Different researchers rechecked if the over dispersion problem in the Poisson regression was eliminated if they used stratified Poison models by smoking status. Accordingly, the log-likelihood ratios 4.03 (p= 0.045) and 55.76 (p<0.00001), for smoker and non-smoker strata respectively, favored the negative binomial regression with interaction instead of the stratified Poisson regression. The results from the negative binomial regression analysis are presented in Table 3. If the confidence interval includes 1, then the result is non-significant and can be interpreted as the mean number of anti-smoking messages recalled at the given category equals the mean response at the reference category. Mean number of anti-smoking messages recalled at the given category equals the mean response at the reference category.

When controlling for sex, age, marital status, education and interaction variables. For a given age, socio-economic status, marital status, smoking and educational statuses, the anti-smoking massage recalling rate for the primary and secondary educated people was around two-thirds (RR = 0.68 and 0.68, respectively) of the anti-smoking recalling rate of university level educated people. Generally, the average number of recalled anti-smoking messages increases with level of education. A highly significant association was found between socio-economic status and

smoking (Chi2 = 13.17, df = 2 and p = 0.014). Lower and middle class nonsmokers' anti-smoking awareness rate is similar to non-smoker upper socioeconomic groups. But the lower socio-economic class smokers' anti-smoking message recalling rate is half that of upper socio-economic class smokers. Generally, non-smokers' anti-smoking messages recalling rate is independent to their level of income. But smokers' anti-smoking messages recalling rate increases with an increase in their income. Men and women's anti-smoking messages recalling rate varies with socioeconomic status. Lower, middle and upper socio-economic class men have a fairly similar recalling rate. But women's anti-smoking message recalling rate increases with income. Men and women's anti-smoking messages recalling rate is associated with their socio-economic status (χ^2 = 6.32, df = 2 and p = 0.0424). Women's anti-smoking message response rate increases with their income, but men's recalling is stable with the variation of their income. When seen from the other angle, it is found that lower socio-economic class men's recalling rate is 1.79 (with 95% CI: 1.12–2.85) times the lower socio-economic class women's recalling rate. But for the other two socio-economic classes, men and women did not show a significant difference.

Table 3. *The negative binomial regression estimates of rate ratios with 95% CIs*

Description	Rate Ratios (R.R)	95% CI	
Age (reference =over 55years			
<25 years	1.36	0.98	1.89
25-55 years	1.05	0.83	1.34
Coupled (reference =single)			
Coupled	0.88	073	1.08
Education (Reference =Tertiary)			
Primary	0.68*	0.47	0.98
Secondary	0.68*	0.53	0.88
Senior Secondary School	0.83*	0.67	1.03
Socio-economic status and Smoking (Reference =Upper income)			
Lower income non-smoker	1.39	0.98	1.99
Middle income non-smoker	0.83	0.61	1.12
Lower income smoker	0.50*	0.03	0.83
Middle income smoker	0.72	0.48	1.07
Socio-economic status and Sex (Reference =Upper income)			
Lower income men	1.14	0.76	1.72
Middle class men	0.88	0.63	1.22
Lower income women	0.61*	0.39	0.94
Middle income women	0.67*	0.47	0.96

*Significant at 5% level

4. Discussion and Conclusion

The issue of health warnings related to smoking is an ongoing campaign and its intended effect has been achieved in certain parts of the world. Nevertheless, people's mind sets need to be constantly fashioned via effective communication, and health warnings related to smoking need to be constantly advertised. The above findings show that marital status and age are non-significant factors for anti-smoking awareness. There is a significant difference between the different races with respect to the number of health warning messages recalled (χ^2 =8.81, df = 3 and p = 0.0320). This result is perhaps a reflection of the societal acceptance of smoking.

Respondents with a lower level of education are more likely to say they are not at all aware of the harmful effects of smoking. This is not surprising, since almost all smoking warning messages are written messages. The messages are not like the commercial adverts which appeal to most people's eyes. In other words, whilst everyone from those with lower education levels to those with higher education levels is exposed to the angers of smoking, the written health warning messages on cigarette packages may be overshadowed by the packaging of the cigarette or the acceptability or smoking within the in group.

The findings show that smokers' response is associated with their economic status. The lower socio-economic class smokers do not recognize the harmful effects of cigarette smoke as non-smokers do. The lower socio-economic class non-smokers' average number recalled messages is 2.5 times that of the lower socio-economic class smokers (RR = 2.5, with 95% CI 1.47–4.11). One possible interpretation of these results is that lower socio-economic class smokers are smoking cigarettes with more ignorance of the danger of smoking than the upper and middle socio-economic class smokers. However, the middle and upper socio-economic class non-smokers' average number recalled messages is similar to the corresponding class smokers (RR = 1.01 with 95% CI: 0.68–1.50 and RR = 0.88 with 95% CI: 0.70–1.10). Also smokers' anti-smoking messages recalling rate increases with the increase of their income. One possible interpretation of these results is that lower socio-economic class smokers are smoking cigarettes with more ignorance of the danger of smoking than upper and middle socio-economic class smokers. Moreover, smokers from the lower socio-economic class are more likely to be unaware of the harmful effects of smoking than the non-smokers of the same socio-economic group.

Women seem to pay more attention to health hazards associated with smoking and diseases as their economic standards improves. The same trend is observed with smokers. This might show that the health warning messages are not well received (or conceived) by lower socio-economic class smokers and lower socioeconomic class women. The other important result reflected in this study is the importance of education for a healthy and well informed society. Given that the Ethiopian illiteracy rate is around 26% of adults over 15 years (6 to 8 million adults are not functionally literate) and the majority of the people are in the lower socioeconomic class, the challenges and future directions of this study are on how to enhance public awareness of the health effects of nicotine and cigarettes to all sectors of the society.

Acknowledgments

The authors would like to thank the Amhara region health Bureau who graciously provided us with the data. We would also like to thank the editor, reviewer and referees for their constructive comments given for betterment of this article during publication.

References

[1] Allison, P. (1999). Logistic regression using the SAS system: Theory and applications. Cary, NC:SAS Institute.

[2] Agresti, A. (2002). Categorical data analysis. New York: Wiley.

[3] Barron, D. (1992). The analysis of count data: Overdispersion and autocorrelation. In V. Peter (Ed.), Sociological methodology. Marsden: Blackwell.

[4] Bennett, W.P, Alavanja, M.C., Blomeke, B., Vahakangas, K.H., Castren K., & Welsh, J.A. (1999).Environmental tobacco smoke, genetic susceptibility, and risk of lung cancer in neversmoking women. Journal of the National Cancer Institute, 91, 14–2009.

[5] Bjartveit, K., & Tverdal, A. (2005). Health consequences of smoking 1–4 cigarettes per day. TobaccoControl, 14, 315–320.

[6] Bjorn, E., & Nielsen, P.V. (1996). Passive smoking in a displacement ventilated room. Indoor Air 1996. Proceedings from: The 7th International Conference on Indoor Air Quality and Climate, July 21–26, Nagoya, Japan, 92–887.

[7] Brook, R.D., Franklin, B., & Cascio, W. (2004). Air pollution and cardiovascular disease: Astatement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. Circulation, 109, 2655–2671.

[8] Brundtland, G.H. (2000). Address at the opening of World No Tobacco Day, World Health Organization. Retrieved June 18, 2007, from http://www.who.int/directorgeneral/speeches/2000/english/20000531_bangkok.html

[9] Cameron, A.C., & Trivedi, P.K. (1998). Regression analysis of count data. New York: Cambridge University Press.

[10] Environmental Protection Agency (EPA). (1992). Respiratory health effects of passive smoking: Lung cancer and other disorders. EPA/600/6-90/006F. Retrieved May 4, 2007, from http://

[11] Fienburg, S.E. (1980). The analysis of cross classified data. Cambridge, MA: MIT Press.

[12] Firth, D. (1991). Generalised Linear Models. In D.V. Hinkley, N. Reid & E.J. Snell (Eds.), Statistical theory and modelling: In honour of Sir David Cox. London: Chapman and Hall.

[13] Fontham, E.T., Correa, P., Reynolds, P., Wu-Williams, A., Buffler, P.A., & Greenberg, R.S. (1994).Environmental tobacco smoke and lung cancer in nonsmoking women. The Journal of the American Medical Association, 271(22), 1752–1759.

[14] Groenewald, P., Vos, T., Normann, R., Laubscher, R, van Walbeek, C., Saloojee, Y., et al. and the South African Comparative Risk Assessment Collaborating Group. (2007). Estimating the burden of disease attributable to smoking in South Africa in 2000. South African Medical Journal, 97(8), 674–681.

[15] Hammond, S.K. (2002). The efficacy of strategies to reduce environmental tobacco smoke concentrations in homes, workplaces, restaurants and correctional facilities. In H. Levin (Ed.), Proceedings from: The 9th International Conference on Indoor Air Quality and Climate, June 30–July 5, Monterey, California, Santa Cruz.

[16] Hanke, W., Kalinka, J., Florek, E., & Sobala, W. (1999). Passive smoking and pregnancy outcome in central Poland. Human Experimental Toxicology, 18, 265–271.

[17] Lindsey, J.K. (1995). Modelling frequency and count data. Oxford: Oxford University Press.

[18] Malats, N., Camus-Radon, A.M., Nyberg, F., Ahrens, W., Constantinescu, V., & Mukeria, A. (2000).Lung cancer risk in nonsmokers and GSTM1 and GSTT1 genetic polymorphism. Cancer Epidemiological Biomarkers Preview, 9, 827–833.

[19] Mc Cullagh, P., & Nelder, J.A. (1989). Generalised linear models (2nd ed.). London: Chapman and Hall.

[20] McCulloch, C.E., & Searle, S.R. (2001). Generalized, linear, and mixed models. New York: John Wiley Inc.

[21] Miller, D.P., De Vivo, I., Neuberg, D., Wain, J.C., Lynch, T.J., & Su, L. (2003). Association between self-reported environmental tobacco smoke exposure and lung cancer: Modification by GSTP1 polymorphism. International Journal of Cancer, 104, 758–763.

[22] National Cancer Institute. (2007). Health effects of exposure to environmental tobacco smoke.Report of the California Environmental Protection Agency. Retrieved May 4, 2007, from http://www.cancercontrol.cancer.gov/tcrb/monographs/10/m10_complete.pdf

[23] Repace, J., Kawachi, I., & Glantz, S. (1999). Fact sheet on secondhand smoke: The 2nd European Conference on Tobacco or Health, the 1st Iberoamerican Conference on Tobacco or Health, February 23–27, Canary Islands, Spain. Retrieved May 22, 2007, from http://www.repace.com/SHSFactsheet.pdf

[24] SAS Institute Inc. (2004). SAS/STAT User's Guide (Version 9.1, Chap. 29, Proc GENMOD). Cary (NC): SAS Institute Inc.

[25] Sitas, F., Bradshow, D., Bah, S., & Peto, R. (2004). Tobacco attributable deaths in South Africa.Tobacco Control, 13, 396–399.

[26] Suh, H.H., Bahadori, T., Vallarino, J., & Spengler, J.D. (2000). Criteria for air pollutants and toxic air pollutants. Environmental Health Perspectives, 108, 625–633.

[27] Witorsch, P. (1998). Effects of environmental tobacco smoke exposure on pulmonary function andrespiratory health in adults: Update 1997. Indoor Build Environment, 7, 4–17.