“Environment-related factors influencing morbidity among economically active household members in urban and rural Nigeria”

AUTHORS	Abayomi Samuel Oyekale

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Abayomi Samuel Oyekale (South Africa)

Environment-related factors influencing morbidity among economically active household members in urban and rural Nigeria

Abstract

Environmental quality is among the factors influencing people's health. In this paper, attempt was made to analyze environment-related factors that influence reported morbidity in Nigeria. During 2013 the Demographic and Health Survey (DHS) data were collected from 38,522 households and analyzed with the negative binomial regression model. The results showed that 5.91% of all households reported that some household members were smoking inside their houses, while 28.47% were sharing toilets. Water was boiled before being used by 2.62% of the respondents. Modern cooking fuel was used by 26.55% of the households. Separate rooms for cooking were reported by 26.68% of the households. However, 1.97% and 1.54% of the households in rural and urban areas respectively reported that one person was sick in the previous one month to the survey. Also, 1.17% and 1.05% of rural and urban households respectively reported that household members had been very sick for three months. Also, in the previous one year, 6.98% and 3.37% of rural and urban households reported that at least an household members had died in the past one year. Out of the included variables in the Negative Binomial regression, years of education, smoke inside the house, access to electricity, age of household heads, use of clean cooking fuel, having place for hand washing, and number of rooms per person showed statistical significance ($p < 0.05$). There is the need to create more environmental awareness on the impacts of environmental quality on health of household members.

Keywords: environment, health, morbidity, Nigeria.
JEL Classification: Q5, I1, Q53, Q56.

Introduction

Although African health policy makers have always desired to minimize the risk exposure of the people's health, recent evidences suggest that prevailing poverty, weakly enforced environmental laws and households' ignorance about safe environmental practices are among the principal limiting forces (World Health Organization, 2003; NEPAD, 2007). Accordingly, recent policies are putting more emphases on identifying and addressing the basic components of the environment that negatively affect people's health (NEPAD, 2007). This is a necessary step for ensuring that many of the Millennium Development Goals (MDGs) are not only attainable, but can be sustained beyond 2015 (UNDP, 2013).

The people's health outcomes are directly linked to several environmental indicators like air and water quality, food safety and avoidance of other contaminants within the society (World Health Organization, 2010). Some statistics have indicated that in 2012, about 2.9 billion people were at risk of contracting respiratory, cardiovascular and cancer diseases due to exposure to indoor air pollution from using unclean energy sources like coals, woods and other forms of biomass either for cooking or lighting (World Health Organization, 2014). Globally, furthermore in 2012 indoor pollution was linked to 4.3 million deaths, while outdoor pollution was linked to 3.7 million deaths (World Health Organization, 2014).

Abayomi Samuel Oyekale, Professor, Department of Agricultural Economics and Extension, North-West University, South Africa.

In Nigeria, the pace of winning the battles over diseases like malaria, dysentery and cholera which are directly related to cleanliness of the environment is very slow. Specifically, between 2008 and 2013, access to clean water slowly increased from 56% to 61%, respectively. This represents 16% shortage from 77% target that is required in order to meet the related Millennium Development Goal (National Population Commission (NPC) [Nigeria] and ICF International, 2014). Similarly, in 2013, access to improved toilet which can be defined as one that is not shared with other households and prevents human contacts with solid wastes was 30.10% (National Population Commission (NPC) [Nigeria] and ICF International, 2014).

These findings have serious implications on health outcomes of many households because the traditional economic thought on health production focuses on utilization of an array of resources for health capital production so that utility would be maximized given some pressing resource constraints. Accordingly, Grossman (1972) developed a model that formed part of the significant bedrock of several other propositions in health demand modeling. Health was conceptualized as a commodity being produced from several inputs. The field model of health further emphasized the interactions between social environment, physical environment and genetic environment in explaining the health outcome of individuals (Evans and Stoddart, 1990).

Research had emphasized disparities in health status of household members due to influences of some community specific characteristics which broadly classified are known as neighborhood disadvantages

(Wright and Fisher, 2003). Some of these characteristics include disparities in health centers, community level stressors such as insecurity, low socioeconomic status or poverty within the society, joblessness, malfunctioning social amenities and utilities, poor urban planning, low standard housing, among others (Attar et al., 1994). Furthermore, Wright et al. (2004) noted that health outcomes can be influenced by environmental factors such as presence of stress inducing activities, domestic and communal violence, and uncertainties in respect of daily life expectations. Therefore, in some instances, presence of such neighborhood disadvantages portends serious motivation for indulging in some control and risk-taking behaviors such as smoking and alcoholism which would have some significant impacts on health status (Acierno et al., 1996).

In Nigeria, several environment-related factors influence people's health. Disparities between rural and urban areas in terms of access to environmental and health services can greatly explain the notion of health inequity and outcomes (Mafimisebi and Oguntade, 2011). Therefore, the extent of physical development of an area can dictate preferences for health among the residents. Rural areas are often sidetracked in provision of basic social services like clean water, electricity and health centers which can obviously explain their disincentives for many health promoting services. Similarly, rapid development of urban areas often brings about disproportionate rural-urban migration with rapid accumulation of the poorest among the urban poor in isolated slum areas.

It is however pathetic to note that urban slums and rural areas can be notoriously characterized by persistent poverty (Centre for Urban Studies (CUS), National Institute of Population Research and Training (NIPORT) and Measure Evaluation, 2006) with peculiar health challenges (Riley et al., 2007). Also, urban slums and rural areas may be characterized by malnutrition, poor sanitation leading to water borne diseases, respiratory infections due to overcrowding and air pollution, occupational health hazards and other internal and external stressors (Haq et al., 2005), teenage pregnancy and sexually transmitted infections, and high rates of alcoholism and smoking (Ahsan, 1998). This paper therefore analyzed the effect of environment-related factors on reported morbidity among Nigerian households.

1. Materials and methods

1.1. Sampling method. The sampling procedures used for collecting the 2013 Nigeria Demographic and Health Survey data that were used in this study had been provided in details by National Population Commission (NPC) (Nigeria) and ICF International (National Population Commission (NPC) [Nigeria] and ICF International, 2014; Nigeria Demographic and Health Survey, 2013). In summary, a total of 40,680 households were selected for the survey, while 943 was the minimum target per state. The first stage of the stratification involved random selection of 893 localities with probability proportional to size. The second stage involved selection of at least one enumeration area (EA) from the selected localities based on population size, and a total of 904 EAs were randomly selected. Household listing was carried out with EAs with less than 80 households supplemented with nearby EAs so that no less than 80 households are within each EA. The third stage involved random selection of 45 households from each EA. In all, 23940 households were sampled from rural areas and 16,740 from urban areas. However, 38,904 of selected households were inhabited, of which 38,522 successfully completed the interview. This gives a response rate of 99 percent. Because of disproportional allocation of samples in some states, sampling weights were calculated so as to ensure representativeness of the selected samples for the entire population.

1.2. Model specification. In order to model the correlates of morbidity within the households, the critical variable was the response to a question on how many of the household members were sick at the time of data collection. The use of negative binomial model is justified since the dependent variable is a count variable. In econometric modeling, this type of variable is to be analyzed using Poisson Regression. In order to determine the appropriateness of this model, the kernel density graph of the dependent variable was plotted as shown in Figure 1.

Poisson regression model can be specified with a random variable Z that is Poisson in its distribution and having parameter μ. The values of Z are integers which can be 0, 1, 2, 3, 4 .. k (Zeileis, 2008). The probability distribution of this model is equal to one and it can be expressed as:

$$\Pr\{Z = z / X_1, X_2, X_3\} = \frac{\exp(-\mu)\mu^z}{z!} \; for \; \mu > 0. \quad (1)$$

The Poisson model takes the form of:

$$\Pr\{Z = z / X_1, X_2, X_3\} = \frac{\exp(-\mu)\mu^z}{z!} \; for \; \mu > 0,$$

$$\log \mu = \alpha + \beta_j \sum_{j=1}^{l} X_l, \quad (2)$$

where α and β_j are estimated parameters. Also, X_ks are the explanatory variables. In Poisson regression modeling, it is assumed that the mean and variance are equal.

$$V(\mu) = \mu. \quad (3)$$

This can be tested by generating some test statistics using Pearson goodness of fit. In the estimated model, the null hypothesis that the distribution was Poisson was rejected. This then called for a search for an alternative model. Therefore, results from negative binomial regression was generated and tested against that of Poisson. This model also has a probability distribution that is equal to one and can be specified as:

$$P(Z = z \mid X_l, k) = \frac{\Gamma(z+k)}{\Gamma(k)\Gamma(z+1)}\left(\frac{k}{k+\mu}\right)^k\left(\frac{\mu}{k+\mu}\right)^z, \quad (4)$$

$y = 0,1,2,...$

with mean μ and shape parameter k; $\Gamma(.)$ is the gamma function:

$$E(\mu) = \mu, \quad (5)$$

$$V(\mu) = \mu + \left(\frac{\pi^2}{k}\right). \quad (6)$$

Let $g(\mu) = \log(\mu)$. (7)

Therefore,

$$g(\mu) = \log(\mu) = \rho + \varphi_j \sum_{j=1}^{l} X_l = \mu^{\rho+\varphi_j \sum_{j=1}^{l} X_l}. \quad (8)$$

In STATA, a likelihood ratio test statistics of alpha equal to zero was generated, which if statistically significant implies that the negative binomial regression model is better than Poisson regression.

2. Results and discussions

2.1. Households' socio-economic characteristics, hygienic practices and reported morbidity. Table 1 (see Appendix) shows the descriptive statistics of households' heads across rural and urban areas. It reveals that average age of households' heads was 45.40 years with standard deviation of 16.18. Household heads from urban areas were significantly older than those from rural area ($p < 0.01$). Also, average household size was 4.64 with standard deviation of 3.11. Fertility was significantly higher in rural areas ($p < 0.01$) where mean of household size was 4.91. Average number of rooms per person in rural and urban areas were 0.92 and 0.96, respectively. These show statistical significance ($p < 0.01$). The average of the total rooms in the combined data was 3.17. However, average number of rooms in rural and urban areas were 3.32 and 2.96, respectively. The ANOVA test also shows statistical significance ($p < 0.01$).

The results of descriptive analysis generally point towards prevalence of more morbidity and mortality among rural households than those from urban areas. Several reasons can be adduced for these. First, rural households in Nigeria are more often the poorest segment of the population without adequate access to health facilities and other social services. Prevailing poverty in rural areas often compels patronage of traditional healers and self diagnosis and treatment of ailments. Many rural areas lack adequate coverage of immunization with low use of family planning, among others (USAID, 2011).

Table 2 shows some environment related variables of the households. It reveals that in rural areas, 6.10% of the households reported that members were smoking inside their houses, as against 5.63% for urban areas. In the combined data, 5.91% of the respondents indicated that some household members were smoking inside their houses. Improved toilet was used by 40.44% of the households. Urban households had higher access to improved toilets (59.49%) when compared with their rural counterparts (27.11%). Also, 28.47% of the combined households were sharing toilet with other households. Availability of certain places for hand washing was reported by 33.64% and 43.10% of rural and urban households, respectively. In the combined data, 37.57% of the households had specific places that were designated for hand washing.

Specifically, disparity between rural and urban households in their access to improved sanitation could as well inform significant morbidity differences because access to improved toilet reduces human's direct contacts with feaces. It had been noted that with better access to improved sanitation and adoption of hygienic practices, there could be significant reduction in incidences of preventable diseases such as diarrhoea, cholera and trachoma (Montgomery et al., 2010). Precisely, one of the leading causes of mortality among children under five is diarrhea (UNICEF, 2012).

Improved water was reported by 65.06% of the combined respondents. However, access to improved water was higher (86.24%) in urban areas than in rural areas (50.24%). Water was boiled before being used by 2.62% of the respondents. However, other methods used for treating water were addition of chlorine (1.60%), strain through clothes (2.12%), and addition of alum (3.88%). However, addition of alum was used by a higher proportion of rural households (4.59%), while a higher proportion of urban households (4.05%) were boiling water. Access to safe drinking water is a major prerequisite for avoiding infection by some water borne diseases. Over the past few decades, there has been serious dilapidation of rural and urban water infrastructure in Nigeria. This, coupled with poor funding has resulted in q poor supply of safe drinking water for the people's use.

The results also showed that 28.47% of the households were sharing toilet with other households. This type of toilet is considered as unimproved source (World Health Organization, 2012) because of higher probability of transmitting infection possibly due to likelihood of being dirty due to inadequate water supply and poor maintenance. Rural households and majority of households in urban slums often share toilets as a result of rising population densities which reduces available space for sanitation systems (Katukiza et al., 2012). Closely related to sanitation system is ownership of a place for hand washing which was reported by 33.64% and 43.10% of the rural and slum area of urban households, respectively. In the combined data, 37.57% of the households had places for washing hands.

Only 26.55% of the households in the combined data were using clean cooking fuel. Access to clean fuel was higher in urban households (49.64%) than in rural areas (10.40%). Also, separate rooms for cooking were reported by 30.05% of urban households as against 24.32% for rural households. In the combined data, 26.68% of the households had separate rooms for cooking.

Table 3 shows the percentage distribution of reported morbidity and mortality in rural and urban Nigeria. It shows that 97.82% and 98.25% of the households reported no sickness among household members in the previous one month. However, 1.97% and 1.54% of the households in rural and urban areas reported that one person was sick in the previous one month to the survey. Also, 1.17% and 1.05% of rural and urban households reported that household members had been very sick for three months. Also, in the previous one year, 6.98% and 3.37% of rural and urban households reported that at least an household members had died in the past one year.

2.2. Effect of environment-related hygienic practices on morbidity. In the modeling of the factors explaining morbidity, several variables were initially included but many of them exhibited strong multicollinearity with each other. This problem was discovered by computing the tolerance when the data were run with Ordinary Least Square (OLS) regression. For retained variables, the results of the tolerance are presented in the fifth column of Table 4, which shows that multicollinearity was not a serious problem given high levels of tolerance exhibited by all variables. In results depicted in Table 4, negative binomial results were preferred over those of Poisson regression given the statistical significance of the likelihood ratio test statistics ($p < 0.01$). Similarly, the likelihood ratio Chi-Square statistics was statistically significant ($p < 0.01$). This implies that the model produced a good fit for the data.

Out of the included variables, years of education, smoke inside the house, access to electricity, age of household heads, use of clean cooking fuel, having places for hand washing, and number of rooms per person showed statistical significance ($p < 0.05$). None of the location variables that were included to capture residence in northern part of Nigeria and urban areas showed statistical significance ($p > 0.05$). Furthermore, although the parameters of access to improved water sources and improved toilet did not show statistical significance ($p > 0.05$), the negative sign of the former was in line with expectation. Access to improved toilet parameter had positive sign which is contrary to expectation. Other variables with statistically insignificant parameters but with expected sign are sharing toilet (0.0452), strain water through clothes (0.2386), use of generating set (0.1176) and having separate room for cooking (-0.0431).

The parameter of years of education indicated that if years of education increases by one unit, the log of number of sick persons in the household will significantly increase by 0.0465 ($p < 0.01$). Educational attainments of household head can be a perfect reflection of occupational engagements and income levels (Kitagawa and Hauser, 1973; Abramson et al., 1982). The premise for understanding the interrelationships between education and health had been perfectly conceptualized in health economics literature (Valkonen, 1989).

Also, for those households where someone was in the habit of smoking inside the house, the log of autonomous value of the model significantly increased by 0.5079. Smoking as a critical behavior that influences environmental quality within the household was reported by 5.91% of all respondents. Also, more household members in rural areas (6.1%) were smoking inside the houses than urban areas (5.63%). Also, morbidity significantly increazed among households where someone was in the habit of smoking. Smoking is one of the fundamental habits leading to several chronic diseases like hypertension, cancer and coronary heart disease. It had been noted that irrespective of the sector of the economy, smoking associated non-communicable diseases are found in several Sub-Sahara African countries (Steyn, 2006). Another major issue of concern however is that inhaling of smokes from cigarettes as a secondary smoker can constitute serious health risks such as cancer and asthma (Gulyani and Talukdar, 2008).

The parameter of access to electricity variable indicated that the log of autonomous parameter for those households with access to electricity significantly reduced by 0.2419 ($p < 0.01$). As household head age increased by one unit, the log of number of sick persons significantly increased by 0.0123 ($p < 0.01$). The households that were using clean cooking fuel

had their log of autonomous parameter being significantly lower by 0.6682 ($p < 0.01$). Similarly, the households with places to wash hand also had their log of autonomous parameter significantly decreased by 0.1610 ($p < 0.05$).

Another vital source of environmental pollution which can affect the health of household members is the source of cooking fuel. Precisely, access to electricity significantly reduced the number of sick household members. Only 26.55% of the households in the combined data were using clean cooking fuel. Among urban and rural households, 49.64% and 10.40% were using modern energy sources. Also, separate room for cooking was owned by 30.05% of urban households as against 24.32% for rural. In the combined data, 26.68% of the households had separate room for cooking. The households that were using clean cooking fuel had significantly lower number of sick people. Unclean cooking energy such as charcoal, wood fuel, crop residues and plants residues is often associated with grey smoke fills which can constitute some breathing difficulties. Due to incomplete combustion resulting from inefficient burning, environmental pollutants such as carbon monoxide, nitrogen oxides, benzene, butadiene, formaldehyde, polyaromatic hydrocarbons and many other health-damaging chemicals. When coal is used, air pollutants such as sulfur, arsenic and fluorine can be releazed during cooking. It had been noted that on daily basis preoccupation by women and their children often makes them to breath in smokes equivalent to consuming about two packs of cigarettes (World Health Organization, 2006).

Finally, as the number of rooms per person increased by one unit, the log of number of sick person in the household significantly decreased by 0.1196. This is expected because overcrowding affects people's health negatively. Sometimes, however, overcrowding may be a reflection of economic destitution because low income households may not possess sufficient money to secure accommodation that would be enough for everybody. The problem is made worse because the poor sometimes exhibit higher fertility than their averagely rich counterparts. Overcrowded environment is a crucial medium for disease transmission (Kimani-Murage and Ngindu, 2007).

Conclusion

Environment-related factors explain morbidity among household members although little attention is often given to some of those critical environmental factors. The findings from this study have emphasized some issues of concern in relation to environmental quality and people's health. It is important to note that more awareness on health impacts of passive smoking in the households should be created. Given the fact that smokers are often at lower health risk than those inhaling smokes from their cigarettes, it is important to enforce existing legislations banning smoking in public places. The governments at all levels should put in place adequate frameworks for improving access of households to improved sources of drinking water, sanitation and energy. Enforcement of environmental sanitation laws would go a long way in enhancing environmental quality within the households. This should include mandatory provision of toilets in every household. Also, there should be creation of awareness on the health implications of persistent exposure to smokes during cooking with solid fuels.

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References

1. Abramson, J.H., Gofin, R., Habib, J., Pridan, H., Gofin, J. (1982). Indicators of social class: a comparative appraisal of measures for use in epidemiological studies, *Social Science & Medicine*, 16, pp. 1739-1746.
2. Acierno, R., Kilpatrick, D., Rsesnick, H., Saund, C. (1996). Violent assault, posttraumatic stress disorder, and depression: risk factors for cigarette use among adult women, *Behavior Modification*, 20, pp. 363-384.
3. Ahsan, H., Underwood, P., Atkinson, D. (1998). Smoking among male teenagers in Dhaka, Bangladesh, *Preventive Medicine*, 27, pp. 70-76.
4. Attar, B.K., Guerra, N.G., Tolan, P.H. (1994). Neighborhood disadvantage, stressful life events and adjustment in urban elementary school children, *Journal of Clinical Child Psychology*, 23, pp. 391-400.
5. Centre for Urban Studies (CUS), National Institute of Population Research and Training (NIPORT) and Measure Evaluation (2006). *Slums of urban Bangladesh: Mapping and census, 2005*. Dhaka, Bangladesh and Chapel Hill, USA; 2006.
6. Evans, R.G., Stoddart, G.L. (1990). Producing health, consuming health care, *Social Science & Medicine*, 31(12), pp. 1347-1363.
7. Grossman, M. (1972). On the concept of health capital and the demand for health, *Journal of Political Economy*, 80(2), pp. 223-255.
8. Gulyani, S., Talukdar, D. (2008). Slum real estate: the low-quality high-price puzzle in Nairobi's slum rental market and its implications for theory and practice, *World Development*, 36, pp. 1916-1937.

9. Haq, S.A., Darmawan, J., Islam, M.N., Uddin, M.Z., Das, B.B., Rahman, F., Chowdhury, M.A., Alam, M.N., Mahmud, T.A., Chowdhury, M.R., Tahir, M. (2005). Prevalence of rheumatic diseases and associated outcomes in rural and urban communities in Bangladesh: a OPCORD study, *The Journal of Rheumatology*, 32, pp. 348-353.
10. Katukiza, A.Y., Ronteltap, M., Niwagaba, C.B., Foppen, J.W.A., Kansiime, F., Lens, P.N.L. (2012). Sustainable sanitation technology options for urban slums, *Biotechnology Advances*, 30, pp. 964-978.
11. Kimani-Murage, E., Ngindu, A. (2007). Quality of water the slum dwellers use: the case of a Kenyan slum, *Journal of Urban Health*, 84, pp. 829-838.
12. Kitagawa, E.M., Hauser, P.M. (1973). *Differential mortality in the United States*. Cambridge, Mass: Harvard University Press.
13. Mafimisebi, T.E., Oguntade, A.E. (2011). Health infrastructure inequality and rural-urban utilization of orthodox and traditional medicines in farming households: A case study of Ekiti State, Nigeria, In: Smigorski K (Ed.), *Health management – different approaches and solutions*. Available from:http://www.intechopen.com/books/health-management-differentapproaches-andsolutions/health-infrastructure-inequality-and-rural-urban-utilization-of-orthodox-andtraditional-medicines-i.
14. Montgomery, M.A., Desai, M.M., Elimelech, M. (2010). Assessment of latrine use and quality and association with risk of trachoma in rural Tanzania, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 104, pp. 283-289.
15. National Population Commission (NPC) (Nigeria) and ICF International (2014). Nigeria Demographic and Health Survey 2013. Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF International. Available from: https://dhsprogram.com/pubs/pdf/FR293/FR293.pdf.
16. NEPAD (2007). Africa health strategy: 2007-2015, Third Session of the African Union Conference of Ministers of Health Johannesburg, South Africa, 9-13 APRIL 2007, available at: http:/www.nepad.org/system/files/AFRICA_HEALTH_STRATEGY(health).pdf. Assessed 27th August 2014.
17. Riley, L.W., Ko, A.I., Unger, A., Reis, M.G. (2007). Slum health: Diseases of neglected populations, *BMC Int Health Human Rights*, 7, p. 2.
18. Steyn, K., Damasceno, A. (2006). Lifestyle and Related Risk Factors for Chronic Diseases In: Jamison, D.T., Feachem, R.G., Makgoba, M.W. et al. *Disease and Mortality in Sub-Saharan Africa*. (2nd edition) Chapter 18. Available from: http://www.ncbi.nlm.nih.gov/books/NBK2290/.
19. UNDP (2013). Assessing progress in Africa toward Millennium Development Goals. MGD Report 2013. Available from: (http://www.undp.org/content/dam/uganda/docs/Africa%20MDG%20report%2020 13%20summary_EN.pdf).
20. UNICEF (2012). *The state of world's children: Children in an urban world*. New York: United Nations Children's Fund (UNICEF).
21. USAID (2011). Urban-rural and poverty-related inequalities in health status: Spotlight on Nigeria Available from: http://www.cpc.unc.edu/measure/prh/research/best-country-fact-sheets/Urban-rural%20country %20fact%20sheet%20 Nigeria.pdf.
22. Valkonen, T. (1989). Adult mortality and level of education: a comparison of six countries. In: Fox J., ed. *Health inequalities in European countries*. Aldershot: Gower Publishing Company, pp. 142-161.
23. WHO (2003). *Poverty and health: A strategy for the African region. World Health Organization regional office for Africa*, Brazzaville.
24. WHO (2014). 7 million premature deaths annually linked to air pollution, Available from: http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/) (retrieved on 20th September 2014).
25. World Health Organization (2006). *Fuel for life: household energy and health*. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.
26. World Health Organization (2010). Environment and health risks: a review of the influence and effects of social inequalities, WHO. Available from: http://www.euro.who.int/__data/assets/pdf_file/0003/78069/E93670.pdf)
27. World Health Organization (WHO) (2014). Burden of disease from Household Air Pollution for 2012. Available from: http://www.who.int/phe/health_topics/outdoorair/databases/FINAL_HAP_AAP_BoD_24March2014.pdf?ua=1.
28. Wright, R.J., Fisher, E.B. (2003). Putting asthma into context: community influences on risk, behavior, and intervention. In: Kawachi, I., Berkman, L.F., eds. *Neighborhoods and health.* New York, NY: Oxford University Press; 2003, pp. 233-262.
29. Wright, R.J., Mitchell, H., Visness, C.M., Cohen, S., Stout, J., Evans, R., Gold, D.R. (2004). Community violence and asthma morbidity: the inner-city asthma study, *American Journal of Public Health*, 9.4(4), pp. 625-632.
30. Zeileis, A., Kleiber, C., Jackman, S. (2008). Regression models for count data in R, *Journal of Statistical Software*, 27(8), pp. 1-25.

Appendix

Table 1. Socio-economic characteristics of the households

	Rural		Urban		Total		ANOVA F-value
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Age of household heads	45.14	16.343	45.75	15.945	45.40	16.183	13.177
Years of education	2.64	2.959	3.77	2.543	3.10	2.850	1.525.742

Table 1 (cont.). Socio-economic characteristics of the households

	Rural		Urban		Total		ANOVA F-value
Household size	4.91	3.187	4.26	2.949	4.64	3.108	420.320
Room per person	0.916	0.8996	0.957	0.9706	0.932	0.9297	18.190
Total rooms	3.32	2.268	2.96	2.191	3.17	2.243	245.783

Table 2. Households' hygienic and environment-related practices

Hygienic practice	% of rural	% of urban	% of total
Smoke in house	6.1	5.63	5.91
Improved water	50.24	86.24	65.06
Improved toilet	27.11	59.49	40.44
Share toilet	19.23	41.68	28.47
Has place for hand washing	33.64	43.19	37.57
Boil water for treatment	1.62	4.05	2.62
Chlorine added to water for treatment	0.9	2.59	1.6
Strain through cloths	2.69	1.31	2.12
Filter before drinking	0.56	0.94	0.71
Solar disinfectant	0.05	0.04	0.05
Water settle before drinking	1.31	1.34	1.32
Alum added to water before drinking	4.59	2.86	3.88
Clean cooking fuel	10.4	49.64	26.55
Has separate room used as a kitchen	24.32	30.05	26.68

Table 3. Reported morbidity among rural and urban households

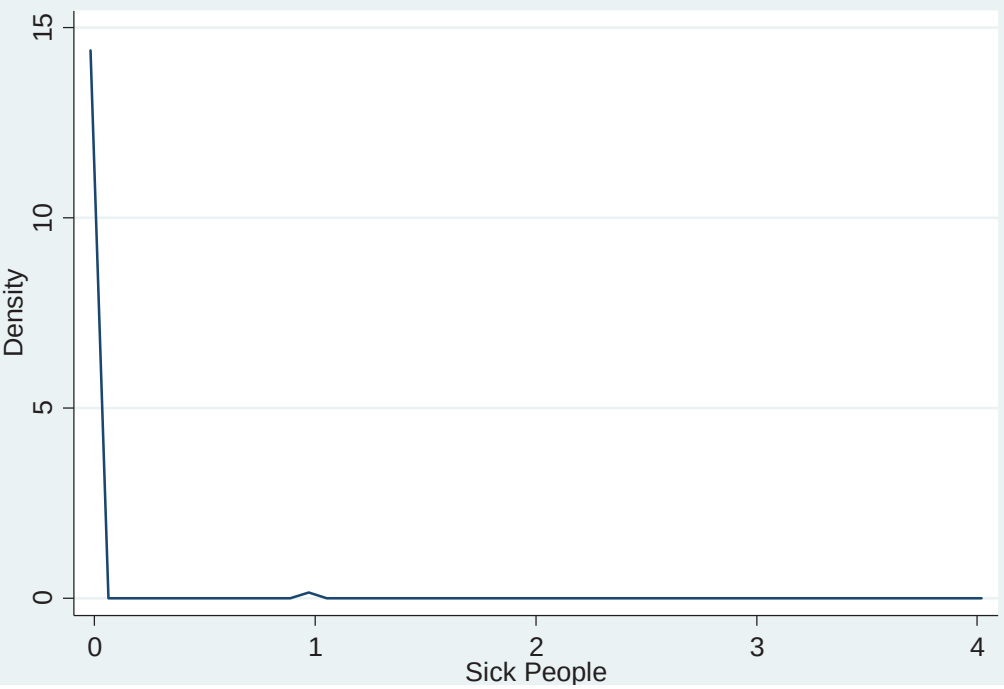
Variables	Description	% of rural	% of urban	% of total
Number of household members that were sick	0	97.82	98.25	97.99
	1	1.97	1.54	1.79
	2	0.19	0.18	0.18
	3	0.02	0.01	0.02
	4	0.00	0.02	0.01
Members have been very sick for 3 months	No	98.83	98.95	98.88
	Yes	1.17	1.05	1.12
	Yes	0.06	0.06	0.06
Member of the household died last 12 months	No	93.02	96.63	94.51
	Yes	6.98	3.37	5.49

Table 4. Results of negative binomial model of the determinants of morbidity (number of sick persons)

	Coef.	Std. err.	*z*	Tolerance
Years of education	.0464611	.0158222	2.94	0.774697
Smoke in house	.5079159	.1338792	3.79	0.989210
North	-.0161141	.0939719	-0.17	0.648608
Urban	.0730377	.0939349	0.78	0.656537
Improved water sources	-.1178684	.0854696	-1.38	0.779906
Improved toilet	.149726	.0883024	1.70	0.747792
Electricity	-.2418714	.0928643	-2.60	0.634026
Gender of household head	.0131688	.1031643	0.13	0.879731
Age of household head	.012306	.0025608	4.81	0.855873
Sharing toilet	.0451789	.0944426	0.48	0.795939
Clean cooking fuel	-.6681908	.1235053	-5.41	0.586642
Has hand washing	-.1609917	.0812209	-1.98	0.965266
Strain water through cloths	.2386243	.1485446	1.61	0.996872
Number of rooms per person	-.119585	.0499109	-2.40	0.939850
Smoking	-6.924238	1645.958	-0.00	0.999073
Generating set	.1175565	.0939079	1.25	0.833129
Has separate place for cooking	-.0431415	.0943982	-0.46	0.868091
Constant	-4.178595	.1947509	-21.46	-
Lnalpha	2.203569	.1208924		
alpha	9.057284	1.094957		

Table 4 (cont.). Results of negative binomial model of the determinants of morbidity (number of sick persons)

	Coef.	Std. err.	*z*	Tolerance
Log likelihood = -4027.9465				
LR chi2(18) = 123.80				
Prob > chi2 = 0.0000				
Pseudo R2 = 0.0151				
No. of obs. = 38522				
Likelihood-ratio test of alpha = 0: chibar2(01) = 280.95 Prob > = chibar2 = 0.000				



Notes: kernel = Epanechnikov, band width = 0.0183.

Fig. 1. Kernel density graph of number of sick people