Vulnerability to air pollution: To intervene or not to intervene

JUANETTE JOHN*, MAMOPELI MATOOANE, RIËTHA OOSTHUIZEN, CARADEE WRIGHT
CSIR Natural Resources and the Environment, PO Box 395, Pretoria, 0001
* Email: jjohn@csir.co.za

Abstract

The Environmental Health Research Group has, amongst other interests, a specific focus on understanding and addressing vulnerability of communities to environmental pollution. No appropriate tools to determine vulnerability to environmental pollution (and specifically air pollution) for the South African context currently exist. This project aimed to develop an integrated risk and vulnerability assessment tool to evaluate the vulnerability of South African communities to environmental pollution, specifically air pollution, exposure. A vulnerability framework, addressing issues of susceptibility, exposure and coping, was applied. A survey consisting of 377 household questionnaires was conducted in eMbalenhle, a low-income peri-urban settlement, and the collected data analyzed. The questionnaire focused on pre-determined 'vulnerability factors', including residence/household, hygiene, sanitation, nutrition and health outcomes. The goal of this survey was to identify possible associations between vulnerability factors and two broad environmental health outcomes, i.e. respiratory (for air pollution exposure) and waterborne diseases. Three statistical techniques were applied to establish whether it was possible to derive a more concise questionnaire.

A subsequent goal of the project entailed intervention development: a complex process requiring a multi-sectoral, multi-disciplinary approach. Appropriate interventions to assist in improving quality of life or mitigating environmental consequences (potentially appropriate opportunities where cost-effective interventions could make a significant difference to the lives of the community and others living under similar conditions) were identified. Dynamics included participation and acceptance of proposed interventions by communities, inclusion and strengthening of existing technologies and involvement of all relevant institutions and stakeholders. A vulnerability interventions approach is being developed which aims to integrate these issues in a case study community incorporating model inputs, technology methods, communication outputs and outcome evaluation. Initial actions include the formation of a 'healthy municipality' steering committee essential for representing all community needs. Final results will assist decision-makers in screening and prioritising vulnerability issues to ensure improved quality of life.

1. Introduction

A community's vulnerability to air pollution is complex because of multifaceted interactions with environmental stressors, intrinsic and extrinsic susceptibility, differential exposure, and coping and adaptation mechanisms (US EPA, 2003). Vulnerability studies regarding air pollution are confined to epidemiological surveys and risk assessments which do not adequately characterize vulnerability across the exposure-disease continuum (US EPA, 2003; Gee and Payne-Sturges, 2004). These fail to account for, among others sources, potential exposures, inherent population susceptibility, and coping mechanisms. This makes the need for new methods which can more adequately address vulnerability apparent. Several frameworks e.g. a health disparities framework or the sustainable livelihoods framework, including a vulnerability context that frames the external environment in which people exist, have been proposed (Gee and Payne-Sturges, 2004; IDS, 2008). The methodological aspects of these frameworks are vague, often borrowing from the existing exposure-response techniques in epidemiological studies.

While the debate concerning the development of new methods that can quantify vulnerability to air pollution continues, the need for informed decision-making based on credible local information is pressing (Payne-Sturges and Breugelmans 2001; Corvalan et al., 2000). This is particularly critical in the context of the developing world where

information is often lacking on characteristics of population vulnerability. Studies have shown that factors including socio-economic profile, social stress, location, nutrition, type of dwelling, and social structures, have a bearing on susceptibility and therefore vulnerability (O'Neill et al., 2003; Wong et al., 2008). This paper describes on-going work to develop a vulnerability assessment and vulnerability interventions framework for the South African context using the eMbalenhle community near Secunda as a case study. The proposed framework overcomes shortcomings of previous methods by considering issues of susceptibility, exposure and coping.

2. Methods

Vulnerability issues as described by three categories (differential exposure, susceptibility, and coping mechanisms) were used to derive an initial vulnerability framework. The vulnerability framework was derived by means of literature review, taking into account the biological plausibility of the association between the factors and categories.

This framework was then used to develop a questionnaire to determine vulnerability to environmental pollution. The questionnaire was administered by trained, local field workers to 377 eMbalenhle households. A pilot study to test questionnaire validity was performed at a similar low-income community, i.e. Cato Crest in Durban.

The questionnaire was intended to capture data about various health outcomes associated with environmental pollution, potential exposure, and factors that would render study subjects vulnerable to environmental pollution exposure. Since this paper focuses on air pollution, the reported self-identified health outcome of concern was respiratory health. Other acute and chronic health effects such as heart disease, arthritis, and tuberculosis were also evaluated but not reported in detail here.

While measurements of air pollution in the community of concern were desirable, this was not possible because of resource limitations. Instead, proxy exposure measures, e.g. type of stove used in the home, types of fuel consumed for cooking and space heating, etc., were used to approximate exposure to indoor air pollution. Other 'vulnerability factors', included type of residence, hygiene, sanitation and nutrition.

Data analysis entailed univariate and multivariate analysis, using Stata release 10 to determine risk or vulnerability factors which were significantly associated with air pollution health outcomes. Structural equation modeling and Bayesian modeling were also employed but are not reported in this paper as results are preliminary.

3. Vulnerability Survey Results

Overall, the study indicated low prevalence rates for all health outcomes with 90% of households considering the health of the family to be good. Prevalence of respiratory conditions measured as asthma, chronic asthma and pneumonia at household level was 6.3 for asthma and 1.9% for both chronic asthma and pneumonia. Prevalence of coughing was 36%. Low rates (between 1 and 7%) were also observed for each of the non-respiratory conditions, namely worms, diarrhoea, bilharzia, malaria, (any) cancer, tuberculosis, depression, heart conditions, diabetes, skin diseases, and arthritis. The prevalence rate for arthritis and high blood pressure was higher at 14% and 26% respectively. Only 11.7% of the households indicated access to medical aid.

The descriptive statistics indicated several factors which may contribute to overall vulnerability of households (Table 1).

Table 1.Potentially important vulnerability factors

Factor	% households
pests problems (rats)	77
pesticides use	73
indoor smoking	45
poor building material (corrugated iron)	63

In addition, more than 70% of households used coal, which is known to cause air pollution, for space heating. This is significantly more than the 4.6% of all South African households as indicated by the 2006 General Household Survey (Pauw et al., 2008), however, the eMbalenhle community is a fairly homogenous, low-income community and not all households make regular use of electricity – 63% indicated that they use electricity as their main source of lighting.

Because of low health outcome observations, asthma, chronic asthma and pneumonia were grouped together as a 'serious respiratory health outcome' group. Multivariate analysis was then performed to determine risk factors that could be significantly associated with this health outcome variable. Results of the multivariate analysis are in the final stages and are likely to include some of the following variables: gender distribution in the household, method of making a fire, presence of existing diseases and the presence of proteins in diet. The results of this process will be a predictive or screening tool, therefore significance of factors has not been the overriding factor for inclusion. Expert opinion and maximum sensitivity/specificity have been regarded to be important.

The final variables selected in this process will be included in a revised questionnaire which will, if found feasible, be used to guide the vulnerability interventions approach.

4. Vulnerability Interventions Framework

During the survey it became apparent that there was a potential for collating vulnerability intervention technologies that could be used to address some of the vulnerability issues identified in the survey, based on the vulnerability factors in the vulnerability framework. The initial vulnerability framework was therefore refined through a systems thinking process (Figure 1) with the purpose of developing a vulnerability interventions approach as shown in Figure 2. This approach will have a level that uses *inputs* from several data sources to assist in selection and prioritisation of vulnerable communities.

Ongoing research is essential and includes the development of a database drawing together relevant technologies, experts and organisations (Figure 2). In order for such an approach to be effective, it needs to be "imbedded within the local decision-making system" (Corvalan et al., 2000). The successful implementation of these technological interventions requires a wide support network that involves various stakeholders including the community, non-government organisations, industry and local government. This is to be addressed by the 'Healthy Municipality approach'. A healthy municipality may be defined as a 'process that requires strong political conviction and support together with equally strong community determination, participation and action' (PAHO, 2008). Lastly, methodologies of evaluating interventions will be assessed to develop guidelines for evaluating interventions.

An important principle guiding framework development is community awareness regarding personal vulnerability. Such data would inform the process of factors perceived to be most important (Ebi et al., 2006) and assist with community acceptance of implemented technologies and interventions. It is imperative to design and implement innovative and cost-effective technological interventions that are socially acceptable. This requires adequate characterisation of the determinants of vulnerability to air pollution (Ezzati et al., 2002). For example, various ways to reduce exposure to indoor air pollution include cooking outdoors, removing children from cooking spaces while cooking, improved ventilation, improved stoves, and the adoption of cleaner fuels (Barnes et al., 2005; Ezzati et al., 2002; Wichmann and Voyi, 2006). However, these alternatives need to be complemented with other interventions to counteract indirect vulnerability factors, such as nutrition, poor education levels, and poor access to health care (Levy et al., 2002; Matooane et al., 2004; Savage, 2007).

5. Discussion and Current Proceedings

The ultimate goal of this project was to assist communities to reduce vulnerability to environmental pollution with a focus on secondary intervention technologies. This was seen as a long-term project with various stages of implementation. Following preliminary analysis of the eMbalenhle survey data, public meetings which included important stakeholders were held to report on the findings of the survey. Community perceptions about their vulnerability status were discussed to assist them to identify areas of concern regarding coping and adaptation, their strengths (or assets) and areas of need. They also identified ways in which they could optimise the usage of existing community assets and facilities towards vulnerability reduction. A process is currently underway to establish a committee to work towards a Healthy Municipality. This committee will play an essential role in ensuring effective implementation of acceptable interventions in the community.

Despite several limitations regarding the survey data, including use of proxy measures for personal

exposure and omitted variables such as psycho-social stress and community resources, potentially important vulnerability factors were identified. For each vulnerability factor, potential intervention technologies are being investigated using the literature, expert opinion and community feedback. The goal is to first identify existing technologies within the community, and then to determine whether they are being used successfully or whether there are any issues that need to be addressed to improve existing technologies. For example, the types of fuels and stoves currently being used in the community may be assessed to identify innovative ways of stove performance improvement. The best technology in terms of the evaluation criteria will be selected for inclusion in the vulnerability approach as a "priority" for implementation. This process will be run in consultation with the Healthy Municipality committee.

Vulnerability to air pollution is a complex issue, as people are exposed to a wide range of environmental pollutants and other risk factors, at different times and places, and each person has different susceptibilities to their effects, and differs in terms of access to health treatment and care (Corvalan et al., 2000). Strategic planning and a systematic approach, together with sustained collaboration between government, industry, the local community, as well as the scientific community are therefore essential for successful implementation of the proposed vulnerability interventions framework. It is hoped that this research tool will allow for informed decision-making, not only on whether to intervene or not, but on how to intervene appropriately to ensure uptake and acceptance by the community.

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MM – Wrote the text, contributed to editing process
JJ – Wrote the abstract, contributed to writing of text; completed the editing
RO – Contributed to the abstract, contributed to the editing process
CW – Contributed to the abstract, text and editing process.

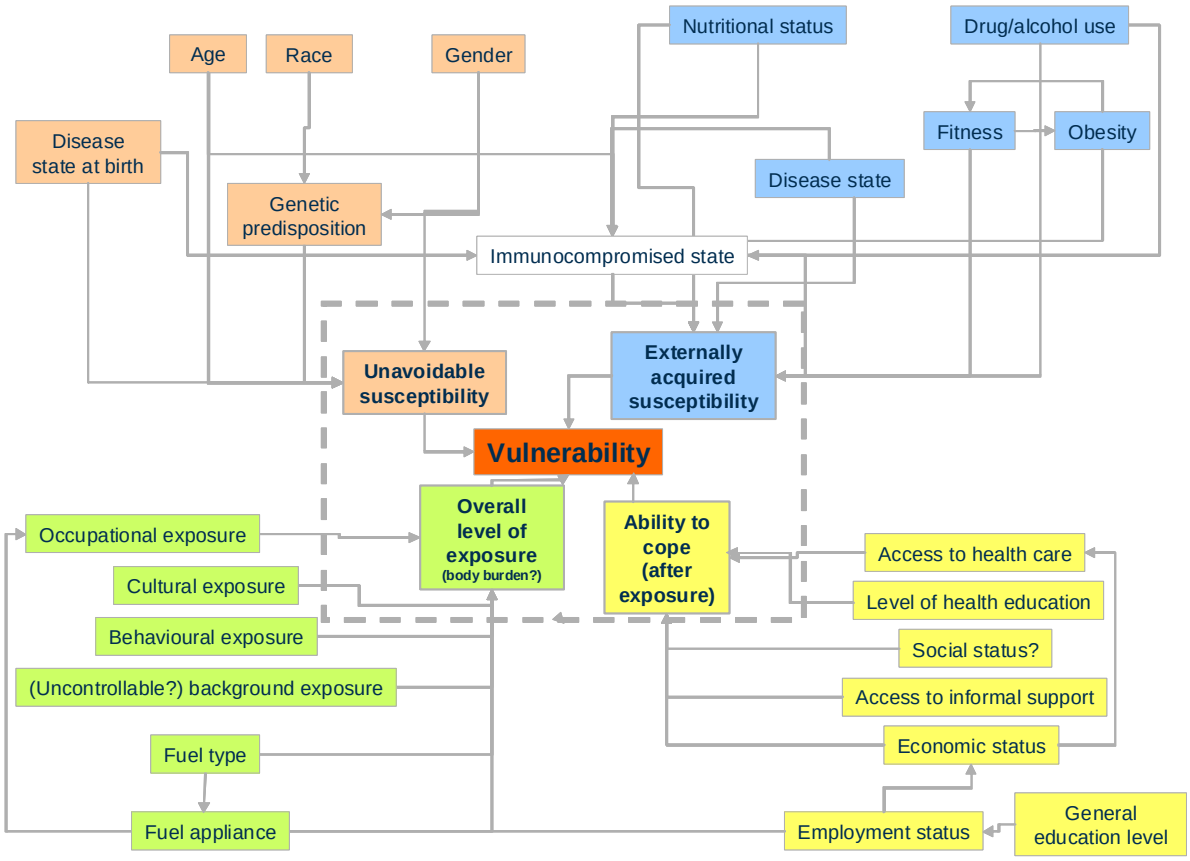

Figure 1. Vulnerability Framework refined through a systems thinking process.

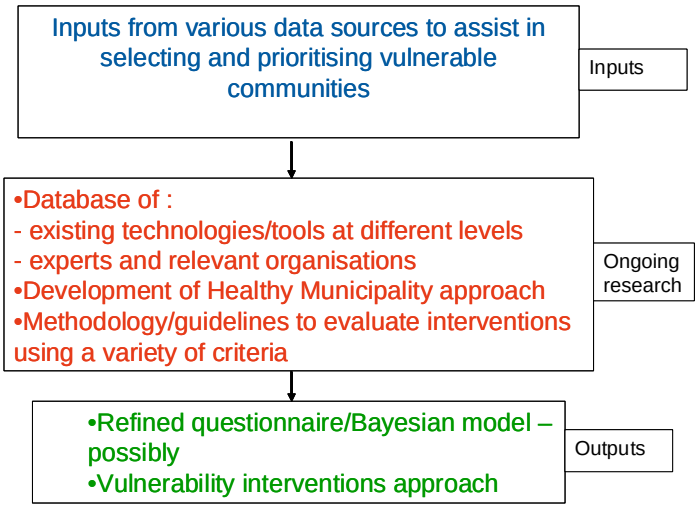

Figure 2. Vulnerability interventions approach