Exposure to Noise in Four Different low income Areas in Western Cape, South Africa

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ABSTRACT

In developing countries, noise exposure and its negative health effects have been little explored. The present study aimed to assess the exposure, annoyance, and sensitivity to noise in adults living in informal settings in South Africa. We developed a land use regression (LUR) model for A-weighted day-evening-night equivalent sound level (L_{den}) using continuous 5-day outdoor noise measurements and geographic information system (GIS) variables of 134 sites to predict noise levels at 364 homes. Noise sensitivity and noise annoyance were assessed by personal interviews. Results were compared to a similar Swiss study (SiRENE study, n=5,369). Main LUR model predictors were road traffic and household density related. However, the model performance was weak (adjusted R^2=0.128). In South Africa, higher percentages of high overall noise sensitivity and high annoyance related to road traffic were found than in Switzerland (women: 35.1% vs 26.9%; men: 25% vs 20.5%). In South Africa women were more highly sensitive to neighborhood noise than in Switzerland (21.1% vs 9.4%), but not men (7.1% vs 7.8%). Life quality of people living in informal settlements is considerably affected by noise exposure.

INTRODUCTION

Annoyance can lead to various adverse non-auditory health effects. The annoyance experienced by a person arises from his/her exposure to noise and his/her sensitivity. While the latter is personal, the former is owed to social and environmental noise sources, and can, therefore be in part controlled [1,2]. In North America, in Europe, and in some Asian countries, the noise and its negative health effects are well understood, whereas little is known about them in developing countries. This present study aimed to give insights into noise exposure, noise annoyance, and noise sensitivity in four different informal settlements (Khayelitsha, Marconi-Beam, Masiphumulele, Oudtshoorn) of the Western Cape Province, South Africa.

The first objective was to develop a land use regression (LUR) model based on one-week outdoor noise measurements and geographical land use data to assess the spatial variability of environmental noise levels. The second objective was to investigate noise sensitivity and noise annoyance among adults in these informal communities in South Africa, and to compare the data collected to data of a similar survey carried out in Switzerland in order to determine to which extend noise is detrimental for those people. Furthermore, the relationship between noise sensitivity and socio-demographic factors (age, gender, education level), and between noise annoyance and socio-demographic factors (age, gender, education level), sensitivity, and outdoor noise was analyzed using logistic analyses for the datasets of the two countries.

RESULTS AND DISCUSSION

In total, 134 valid long-term outdoor noise measurements were obtained from 127 households, five schools, and one reference site which corresponds to the official air pollution measurement site of the community. We developed a LUR model for A-weighted, day-evening-night equivalent sound level (L_{den}) using continuous 5-day outdoor noise measurements and geographic information system (GIS) variables of 134 sites to predict long-term spatial variation of outdoor noise levels at 364 homes. The final model contained two different road variables (length of big roads within a 200m buffer, length of medium roads within a 25m buffer), and three predictor variables related to land use (household density, commercial land use, industrial land within a 50m buffer). The LUR model demonstrates road traffic to be an essential noise predictor in the study areas, like it was shown by previous studies in Europe, and Northern America [3,4]. However, only 13% of the outdoor noise exposure variability was explained by the LUR model. There is a good possibility that such a low value was linked to GIS data inaccuracy. Informal settings in South Africa are often constantly changing (new roads and buildings constructions). As a consequence, the GIS data used for this study may not be up-to-date. Beside traffic, the household density was also a significant noise predictor variable. This result was expected because these areas are crowded, and thus the noise coming from the neighborhood is substantial. However, derivation of GIS predictors as a surrogate for neighborhood noise is tricky, and thus a reason for the low noise variability explained by the LUR model may be the underestimation of the neighborhood noise by the GIS variables available. Both land use variables were not statistically significant and thus less important in our model. The NDVI variable which was the most important one in the LUR models developed for Montreal, Canada, was not retained in the South African LUR model [4]. Although the adjusted R^2 of the LUR model was low, we used this model for predicting the noise at all sites where noise sensitivity and noise annoyance questionnaires were carried out (n=364). As a result, we obtained a low correlation between predicted noise and measured noise (R^2=0.163). However, we could observe that the correlation was not the same between the four areas. The estimates noise levels were the most accurate for Khayelitsha, and for Marconi-Beam, where noise levels are higher. Khayelitsha is the most crowded area with most of the traffic, followed by Marconi-Beam. This indicates that LUR models are not suitable to model noise in areas with lower noise levels, and presumably less strong noise sources as in Masiphumulele and Oudtshoorn.

Unexpectedly, the percentage of highly sensitive people (%HS) to noise (overall sensitivity) as well as the percentage of highly annoyed people (%HA) by road traffic and the %HA by neighborhood noise were higher in the surveyed population in South Africa than in Switzerland. Moreover, the %HA by aircraft (0.2%) and by factories/industries (1.8%) demonstrate that the sampled population in South Africa did not answered the questions with extremely high values, which renders the South African results comparable to the Swiss ones. However, in contrast to South Africa, in Switzerland questions were focused on noise sensitivity and noise annoyance experienced at home. The South African sampled inhabitants were, depending on their gender, between about 5 to 10% more highly sensitive (HS) than in Switzerland. Nonetheless, the sample in Switzerland was more HS to noise at home than the South African ones. This might be owed to the difference in quality of life in both countries, and the importance given to the place of residence. When looking at the annoyance, participants in South Africa were, depending on the gender, about 7-8% more highly annoyed (HA) by road traffic, women were nearly 12% more HA by neighborhood noise, while men were 0.7% less HA by neighborhood than the sampled population in Switzerland. There are several factors that could explain these discrepancies between South Africa and Switzerland. The first one might simply be that the outdoor noise levels were higher in South Africa than in Switzerland. Unfortunately, no comparison between the noise exposure in South Africa and in Switzerland was possible because a factorial design was used in Switzerland, selecting the same number of observation per noise levels category. Secondly, one would expect at equal outdoor noise levels, higher indoor noise levels in South Africa because of the low construction quality of the dwellings. Most of them are made of wood, and have a piece of corrugate metal as the roof, whereas in Switzerland the buildings are usually well isolated. Thirdly, surveyed people in South Africa might spend more time outside than the sampled population in Switzerland, and thus be exposed to higher levels of noise.

Quality of life plays an important role for noise sensitivity and noise annoyance. The WHO had already mentioned that not only noise exposure, but also factors of psychological, economic, and social nature are related to noise annoyance [5]. People in these informal settlements had a precarious livelihood. Such social conditions might lead to an accumulation of burden and thus lower noise sensitivity as well as noise annoyance thresholds. This is what we have actually observed. General noise sensitivity and noise annoyance were higher in South Africa than in Switzerland. This suggests that precarious conditions make the population more vulnerable to other external nuisances like noise, and implies that adequate noise protection is not only to be considered in well-developed settings, but on a global scale. Noise sensitivity and annoyance may not only be higher in impoverished areas, but in addition noise may additionally hinder quality of life thus initiating a vicious circle.

The logistic regression for HS (overall noise sensitivity) developed using the South African data did not show any statistically significant relationship with the explanatory variables gender, education level, and age. The non-significant results were caused by the relatively small number of study participants because of missing data in the socio-demographic questionnaire. However, likewise no statistically significant relationship between these variables had been reported by Okokon *et al.* [2]. The same model built with the Swiss data showed a statistically significant relationship with gender, education level, and age. Whereas the overall HS decreased log-linearly with increasing education level, and was also lower in age categories above 30 years old in South Africa, it increased in Switzerland. However, in both countries men were less HS than women. Similarly to the overall HS model, models for HA by road traffic, as well as for HA by neighborhood noise in South Africa, did not show many statistically significant relationships.

In South Africa, the HA by road traffic log-linearly decreased with the overall sensitivity score, and the noise (L_{den} measured or predicted), while it log-linearly increased in Switzerland with the same variables as aforementioned. Anew, men were less HA by road traffic than women in both countries, and equally in both countries, the HA by road traffic log-linearly increased with the education level increasing. The relationship between HA by road traffic, and the age was again opposed in both countries. In South Africa, surveyed people above 30 years old tended to be less HA by road traffic, whereas they were more HA by road traffic in Switzerland. In the model with South African data, and L_{den} measured, gender and education variables are statistically significant, and partly support Okokon *et al.* statement about individual attributes influencing noise annoyance [2]. The two logistic models realized for the HA by neighborhood noise in South Africa, and the one realized for the HA by neighborhood noise in Switzerland (computed from the three source-specific transportations L_{den} – road, railway, aircraft – available meant to represent the background noise exposure average, as no noise exposure was specifically modeled for neighborhood noise) showed a log-linear, and positive relationship with the overall sensitivity score, and with the noise (L_{den} measure, predicted, and computed, respectively). Okokon *et al.* also obtained a positive association between HA and noise, and HA and sensitivity [2]. Moreover, the association between HA by neighborhood noise, and the noise variable was the strongest relationship observed in the South African model with L_{den} measured, as well as in the Swiss logistic model with L_{den} mix. This finding is also in accordance with the WHO report [5]. In the same three models, males were less HA by neighborhood noise than women. Interestingly, the effect of eduction differed between the Swiss and South African data. In Switzerland, HA by neigbourhood noise was not related to education. In South Africa, HA by neighborhood noise log-linearly decreased with a higher education. It may be that in South Africa the living place and thus the quality of life widely differ according to the education level, which is usually linked to the income. On the other side, these people may also spend less time at home as they are working, and thus be less disturbed by neighborhood noises. A cultural effect is also possible. Certain social bias might be taken into consideration. The South African model with L_{den} measured, and the Swiss model displayed less HA by neighborhood noise when older than 30 years old, except in Switzerland for the age category 30-39 years old.

A limitation of this study was the LUR model, which was developed based on measurements conducted over a period of six months and not concurrently at all sites. Different results might be obtained for other seasons. For instance, different weather conditions may affect the noise sources, and the noise levels via noise propagation. Furthermore, the study population was selected for a longitudinal cohort study on air pollution and respiratory health outcomes among pupils, and not specifically for noise pollution. It should be noted that the sampled participant in the South African cohort were parent or caregiver of school children participating in an air pollution study and thus not a random representation of adult from these four informal settlements. Moreover, this cohort had a greater proportion of females than males, as interviews were conducted during the day, time at which men were absent, usually at work, whereas the women were staying at home. This may lead to bias when comparing percentages of HS or HA men between Switzerland and South Africa, since there were only 7.7% of males in the South African cohort, which corresponds to 28 men. Finally, the low proportion of socio-demographic data obtained from the noise sensitivity and noise annoyance questionnaires respondents restricted the power of the logistic models.

On the other side, this study is the first to give rise to noise measurements over several days in South Africa, more especially in informal settlements. In addition, no LUR model for noise had yet been developed with data from the African continent, one previous LUR model having been developed for air pollution in Western Africa [6]. For the first time noise sensitivity and noise annoyance data were compared between an African country, and a European developed country. No previous study had explored the effect of noise pollution in such an extent.

CONCLUSION

This study revealed informative insights about noise sensitivity, and noise annoyance among people living in informal settlements. Noise sensitivity and high noise annoyance seem to be higher in low and middle incomes settings than in Switzerland. Relatively neighborhood noise has more negative effects in developing areas than in developed countries. Thus, along with other measures, adequate noise protections should be considered when improving the living conditions in such areas.

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