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Environmental Dust Exposure from Gold Mine Dumps and Chronic Respiratory Conditions

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in Community Health (Occupational Medicine)

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Declaration

I, Samantha Iyaloo, declare that this research report is my own, unaided work. It is being submitted as per the requirements for the degree of Master of Medicine in the Specialty of Community Health (Occupational Medicine). It has not been submitted for any other degree or examination at this or any other university.



Samantha Iyaloo Date: 17 October 2019

Dedication

I dedicate this research report to my loving husband, Prevlin Naidoo, for your continuous support and encouragement. Lastly, I dedicate this research to my sons, Preethan and Yuvesh Naidoo. I pray for you, the love of learning. You are all, my greatest joy, inspiration and blessing.

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Lastly, to the community of Riverlea and Ennerdale, for your participation in this research.

MMed submission format

This MMed research report is submitted in the format of a submissible research article. Respiratory Health in a Community Living in Close Proximity to Gold Mine Waste Dumps, Johannesburg, South Africa, article will be submitted to the Environmental Health Perspectives Journal. This is to certify that the article conforms to the author guidelines for the Environmental Health Perspectives Journal. The author guidelines are available at https://ehp.niehs.nih.gov/authors/hub and are included as Appendix IV. The research protocol for this MMed research – was approved by University of the Witwatersrand's Human Research Ethics Committee (medical) – the protocol is also attached (Appendix II).

Contribution of the candidate to the paper

We, the co-authors, certify that Samantha Iyaloo is the first author of this paper. She is responsible for the content of the paper and worked on the following areas regarding the research execution and writing of the article:

- Conception and design of the work outlined in the paper,
- Data collection,
- Data analysis and interpretation of the results,
- Writing of the drafts of the article, and
- Writing of the final article.

Professor David Rees

Role: Conceptualisation, MMed supervision, review of data analysis, review of draft and final manuscripts

Signature: ___ _____19/3/2019___Date:

Dr Spo Kgalamono

Role: Conceptualisation, MMed supervision, review of draft and final manuscripts

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Associate Professor Nisha Naicker

Role: Conceptualisation, field work co-ordination, review of draft and final manuscripts

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Role: Conceptualisation, field work co-ordination, data collection, data analysis and statistical support and review of final manuscript

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Presentations/publications from this study

This paper has been accepted for oral presentation at the Epidemiology in Occupational Health (EPICOH) Conference in New Zealand (29 April - 2 May 2019). The candidate was awarded a scholarship for participation.

Respiratory Health in a Community Living in Close Proximity to Gold Mine Waste Dumps, Johannesburg, South Africa

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Declaration of competing financial interests

The authors declare no actual or potential competing financial interests.

Abstract (300 words)

Background: People living in close proximity to gold mine waste dumps are exposed to wind-borne, silica-rich dust. The effects on respiratory heath consequent on this exposure are largely unknown.

Objective: To examine associations between environmental gold mine dump dust exposure and respiratory health in adults.

Methods: A cross-sectional study was done with 93, 133 and 84 people in high (home < 500m from a mine dump), moderate (500m-1.5km) and low (> 15km) exposure groups respectively. We calculated a cumulative exposure index (CEI) based on exposure groups and years of residence in them. Participants were interviewed about respiratory symptoms, had chest X-rays and spirometry. We used multivariate logistic regression to examine the effect of dust exposure on respiratory symptoms and conditions, and multiple linear regression to determine if CEI was associated with percentage predicted FEV1 and FVC. We adjusted for socioeconomic status, smoking, biomass fuel use and occupational exposure.

Results: No participant had radiological features of silicosis. The high relative to the low exposure group had significantly elevated adjusted odds ratios (aORs) for upper respiratory symptoms (aOR: 2.76, 95% CI: 1.28, 5.97), chest wheezing (aOR: 3.78; 95% CI: 1.60, 8.96) and spirometry-diagnosed COPD (aOR: 8.17; 95%CI: 1.01, 65.85). These findings were similar for the high relative to medium exposure group, but no significant associations were found for the medium versus low exposure group. Chronic bronchitis and tuberculosis risks did not differ significantly among the groups. Using CEI to estimate exposure produced similar results. Linear regression showed that CEI was not associated with % predicted FEV1, but, surprisingly, FVC% was positively associated with the index.

Conclusions: Residents residing < 500m from mine dumps had elevated risks of respiratory symptoms and COPD, but there was no evidence of a negative association between FEV1 or FVC and mine dump dust exposure.

Keywords

Environmental siliceous dust exposure, COPD, Riverlea, respiratory symptoms

Introduction

In South Africa, mining operations in the Witwatersrand gold basin have resulted in approximately 270 tailings storage facilities, more commonly referred to as gold mine waste dumps, or, colloquially, mine dumps, around Johannesburg (AngloGold Ashanti 2008; Hobbs et al. 2010). These mine waste dumps are mostly unlined and many are not vegetated; they are thus a significant source of air-borne dust. Inhalable particulate matter has been shown to travel up to two kilometres downwind of mine waste dumps and up to half a million people who live around these waste dumps may face health risks because of it (Kneen et al. 2015).

Gold mine waste dump dust, specifically around the Witwatersrand area, has been shown to have a high crystalline silica content, predominantly in the form of quartz (Andraos et al. 2018; Belle 2005; Malatse and Ndlovu 2015). The composition of the mine dump material is, however, complex: although silica predominates, many metals, minerals and chemicals have been identified in the waste material (Aucamp and van Schalkwyk 2001; Vermeulen 2007).

A fraction of the particulate matter (PM) in the mine dump material is fine enough to be inhaled to the gas exchanging region of the lung. For example, Andraos et al, (2018) found large numbers of particles < 10 µm in 63 bulk samples collected from five waste dumps in the Witwatersrand area (four in Johannesburg and one in Klerksdorp, North West Province) (Andraos et al. 2018). Substantial proportions of the particles < 20 µm were in the nanoparticle size range. Also in the Witwatersrand, Ojelede et al (2011) found the volume of particles ≤ 5 µm and ≤ 10 µm in older gold mine dump material (slimes) to be 6-17% and 22-38% respectively. Additionally, the reworking of gold mine dumps for further gold extraction using newer technologies has resulted in an increase in the proportion of inhalable particles in the tailings material (Kneen et al. 2015). Parts of the dump material are thus within the respirable fraction - in occupational hygiene nomenclature (inhalable particulate matter 10 micrometres or less (PM_{10}) more generally), and thus fine enough to cause the diseases associated with respirable crystalline silica (RCS).

Research in the Witwatersrand area has shown that environmental standards for PM_{10} have at times been exceeded in the vicinity of these gold mine waste dumps (Kneen et al. 2010, 2015; Ojelede et al. 2012). The distance the dust may travel is, however, weather-dependent. Ojelede et al. (2012) found

that South African Department of Environmental Affairs (DEA) 24-hour threshold value for PM_{10} of 120 µg/m^3 was not exceeded, except where wind speeds reached 7 m/s. Notably, concentrations reached 2160 µg/m^3 (on one occasion during a 5-day measurement period), which is 18 times the DEA's threshold value. The South African standard is lenient compared to the World Health Organization's which is 50 µg/m^3 (WHO 2005).

There is no statutory or guidance exposure limit value for non-occupational RCS in South Africa. However the United States Environmental Protection Agency (1996) has set the limit at 5 µg/m^3. Kneen et al. (2010), found that PM_{10} hourly average concentrations within 1.5 kilometres of mine dumps in the Witwatersrand area ranged between 5 and 377 µg/m^3 during a four-week period of monitoring ambient air-borne particles. Their modelled estimates determined that environmental exposure would be likely to exceed South African occupational exposure standards for RCS of 100 µg/m^3 for 845 hours/year, which is equivalent to 106 eight-hour shifts. Andraos et al. (2018), found that the 24-hour average ambient crystalline silica PM_{10} concentrations, ranged from 4.63 µg/m^3 to 19.40 µg/m^3 in a study of exposures around gold mine dumps in Johannesburg.

Little is known about the respiratory health effects of exposure to the siliceous gold mine dump dust. In particular, no studies have examined respiratory diseases commonly associated with silica, such as silicosis, tuberculosis and chronic obstructive pulmonary disease (COPD) (Rees and Murray 2007; Taylor, Cullinan, Blanc 2016) or decline in spirometric parameters such as forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). The South African studies that have been done relied on symptom reporting; they have shown increased symptoms associated with proximity to gold mines or dumps (Nkosi et al. 2015a, 2015b). A Portuguese health survey of residents living near an abandoned gold mine also found a higher prevalence of respiratory and irritant-induced symptoms compared to a community 45 kilometres from the gold mine (Mayan et al. 2006).

The study reported here was motivated by the paucity of research on the respiratory health effects on residents in close proximity to gold mine waste dumps using objective measures of health outcomes such as spirometry and chest X-rays. This study thus aimed to examine the associations between respiratory conditions and residence near gold mine dumps.

Methodology

Study population and setting

We conducted this cross-sectional household survey as part of a larger panel study called the Johannesburg Health, Environment and Development (HEAD) study; the methodology and objectives of which are described elsewhere (Mathee et al. 2010). We did the study in the Riverlea and Ennerdale townships of Johannesburg, South Africa. Ennerdale was not part of the HEAD study but was added to provide a comparison population for our study. Riverlea is a low income predominantly "mixed race" (coloured in South African parlance) community with a population of about 16 230 at the time of the study, who lived in approximately 4 208 households built around and in close proximity to established gold mines. These gold mines predate the community and have ceased operation, but their waste dumps remain (Statistics South Africa 2012; Makene 2007). Ennerdale is 34 kilometres from Riverlea (Figure 1) and had a population of about 71 815 in approximately 19 844 households. We chose Ennerdale as a low-exposed population based on its large distance from a mine or mine dump (> 15 kilometres), absence of near-by factories and for its similar socio-demographic profile to the Riverlea population (Statistics South Africa 2012). We selected households using aerial town planning maps of the City of Johannesburg and by randomly generated numbers produced by "Microsoft Excel" (Excel version 2016)

Exposure estimation

We estimated exposure using two methods. The first was based on the household's distance from the nearest gold mine waste dump. Riverlea is divided into two areas by a railway line. Residents living on the side of the railway line closest to the old gold mine lived within 500 metres of a mine waste dump boundary. We defined this group as our high exposure group. The rest of Riverlea lies more than 500 metres but within 1.5 kilometres of the gold mine waste dump boundary and we defined this group as the medium exposure group. The Ennerdale community was regarded as the low exposure group.

For the second exposure estimation method, we derived a cumulative exposure index (CEI) for each study participant using the product of the number of years lived in each exposure group and a dust intensity weighting for each of the three groups. We established the intensity weighting by using the modelled dust levels for communities around gold mine dumps as determined by Ojelede et al. (2012). Ojelede used predictive models of PM_{10} concentrations in the area surrounding mine dumps in Riverlea and further away, using actual particulate matter concentrations collected closer to the mine dumps. PM_{10} dust measurements collected from communities closest to a gold mine waste dump (in the high exposure group) had a predictive model value of 60 µg/m^3. Those further away from the mine dump (in the medium exposure group) had a predictive model value of 40 µg/m^3, and those outside the demarcated zone surrounding gold mine dumps (similar to our low-Ennerdale exposure group) had a predictive model value of 10 µg/m^3 of PM_{10} dust. Based on the above, residents of Riverlea in the high and medium exposure groups were given an intensity weighting of six and four respectively, and residents in Ennerdale (low exposure group) were given an intensity weighting of one. CEIs for study participants with one or more category of exposure (in cases where residents moved from one exposure area to another exposure area) were calculated using the following formula:

$$CEI = [\big(residence(1)\ weighting\ x\ years\ \ of\ stay(1)\big) + (residence(i)\ weighting\ x\ years\ of\ stay(i))]$$

Health assessment

Following written informed consent, residents older than 18 years completed a questionnaire administered by a trained interviewer in their preferred language. The questionnaire covered demographic information, residential history, occupational and domestic exposures, smoking history and the outcomes of interest as detailed in Table 1. Participants who completed the interview were invited to a centrally located community hall for chest X-rays and spirometry to objectively identify features of chronic lung disease (particularly airflow limitation on spirometry and tuberculosis and silicosis on chest X-ray). We conducted the investigations over two weekends in July 2017. Posteroanterior chest X-rays were taken using South African National

Accreditation System (SANAS) approved service providers. Chest X-rays were read blind to exposure group by two occupational medicine specialists and one radiologist who were all experienced and had received training in the International Labour Organization's Classification of Radiographs of Pneumoconioses (Elmes 1971). Spirometry was done by experienced, accredited and trained service providers according to the 2005 ATS/ERS standards (Miller et al. 2005). Percentage predicted forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) values were calculated using the Global Lung Function Initiative (GLI) 2012 reference equations (Quanjer et al. 2012). If the FEV1/FVC ratio was < 70% and/or FEV1 was < 80% of predicted, a bronchodilator was administered. The lower limit of normal of the FVC, FEV1 and FEV1/FVC were calculated using the GLI 2012 reference equations.

Statistical analysis

We conducted the analyses using Stata version 14 (Stata Corporation, College Park, Texas, USA). We used Chi-square tests to assess differences across exposure groups. A *p*-value < 0.05 was used as a pre-determined significance level. Associations between the respiratory outcomes of interest (listed in Table 1), exposure group and CEI were estimated by multivariate logistic regression while controlling for the *a priori* confounders of age; sex; pack-years of smoking (average number of cigarettes smoked/day x years of smoking), an occupational history of exposure to vapours, gas, dust or fumes; biomass fuel use; tuberculosis and socio-economic status. We included a previous history of tuberculosis or evidence of radiological tuberculosis as a confounder for COPD since tuberculosis may produce airflow limitation similar to COPD on spirometry. We also conducted a sensitivity analysis excluding those with tuberculosis while assessing the effect of CEI on COPD. We used multiple linear regression to estimate the effect of CEI on the percentage predicted FEV1 and FVC. Modelling with robust standard errors was used to account for deviations in the assumptions. Interactions for smoking status on the relation between CEI and the percentage of predicted FEV1 and FVC were investigated while conducting the multiple linear regression.

Ethical approval and permissions

We obtained ethical approval from the University of the Witwatersrand's Human Research Ethics Committee (Medical) (M150550). We obtained written informed consent from each subject and referred all study participants with abnormalities (including abnormal spirometry detected during the examination), to the nearest healthcare facility for further investigation and management if required.

Results

Three hundred and eighty-one residents from separate households were selected to participate in the study; 55 were not available and 16 declined, resulting in 310 (81%) positive responses. Table 2 shows that of these 310 participants, 93 (30.0%), 133 (42.9%) and 84 (27.1%) were in the high, medium and low exposure groups respectively. All 310 study participants completed a questionnaire, but fewer had chest X-rays: 55 (59.1%) in the high; 69 (51.9%) in the medium; and 53 (63.1%) in the low exposure group. We found no significant differences in the symptoms (cough and shortness of breath) between those who came for the chest X-ray compared to those who did not come for this investigation. A further 12 (21.8%), 10 (14.5%) and 6 (11.3%) study participants from the high, medium and low exposure groups respectively, did not do spirometry due to contra-indications, the most common of which were severe hypertension or suspected active tuberculosis.

Table 2 provides the socio-demographic, environmental and occupational characteristics of the study participants by exposure group. In all the exposure groups, close to two-thirds of the study participants were women. A smaller percentage of the low exposure group smoked (46.4%) than their high exposure counterparts (64.5%). Other notable differences between the high and low exposure groups are the smaller percentage with tertiary education (5.5% vs 21.4%), lower percentage of highest category monthly household income (4.4% vs 19.0%) and longer duration of residence in the exposure group (38 years vs 16 years). Biomass fuel use was lowest in the high exposure group (4.9%), but this group had by far the highest percentages with occupational exposure (high 53.9% vs low 17.9%).

Table 3 summarises the respiratory symptoms and conditions of interest. The percentages of individuals with symptomatology did not differ significantly across exposure groups, except for chronic bronchitis which was most prevalent (20.4%) in the high exposure group ($x^2 = 8.06$, p-value = 0.018), and a wheezy chest, also most common - at 43.5%- in this group ($x^2 = 17.49$, p-value <0.01). The prevalence of radiologic evidence of probable past or current tuberculosis was 10.9%, 17.4% and 7.5% in the high, medium and low exposure groups respectively (x^2 =

2.84, *p*-value = 0.24). COPD diagnosed on spirometry was more common in the high exposure group (18.6%) than in the in the medium (10.2%) and low (10.6%) exposure groups, but not significantly so (x^2 = 1.87, *p*-value = 0.39). The median percentage predicted FEV1 and FVC were highest in the high exposure group (98.0% and 102.0% respectively). We used crude odds ratios to examine the effect of exposure category on 11 health outcomes. The relative effect estimates and their 95% confidence intervals are presented in Table 3. There were significant differences in the high versus low exposure groups for upper respiratory tract symptoms, ocular symptoms and a wheezy chest. Significant associations in the high vs medium exposure groups were upper respiratory tract symptoms, chronic cough, chronic bronchitis and a wheezy chest. There were no significant differences when comparing the medium and low exposure groups.

We did multivariate logistic regression, shown in Table 4, which revealed significant differences between the high and low exposure groups in the adjusted risk of upper respiratory tract symptoms (aOR: 2.76; 95% CI: 1.28, 5.97), ocular symptoms (aOR: 4.68; 95% CI: 1.87, 11.68), wheezy chest (aOR: 3.78; 95% CI: 1.60, 8.96) and COPD diagnosed on spirometry (aOR: 8.17; 95% CI: 1.01, 65.85). We conducted a sensitivity test by excluding those with COPD who either had a previous history of tuberculosis or those with radiological evidence of tuberculosis. This analysis produced a similar aOR but wider confidence intervals (aOR: 8.83; 95% CI: 0.70-112.08). Significantly elevated aORs for the high relative to the medium exposure group were found for upper respiratory tract symptoms (aOR: 2.12; 95% CI: 1.01, 4.42), ocular symptoms (aOR: 3.01; 95% CI: 1.32, 6.89) and wheezy chest (aOR: 3.60; 95% CI: 1.60, 8.11). We found a negative association for chronic cough and being part of the medium relative to the low exposure group (aOR: 0.36; 95% CI: 0.17, 0.77).

We calculated crude and adjusted odds ratios for respiratory health outcomes using the cumulative exposure index (CEI) as the exposure variable. The median of the CEI was 80 exposure group-years (IQR: 4-408) and was 228 (IQR: 90-408), 80 (IQR: 12-260) and 16 (IQR: 4-44) exposure group-years for the high, medium and low exposure groups respectively. Table 5 shows that increased CEI was associated with small but significantly elevated risks of upper

respiratory tract symptoms (aOR: 1.0034; 95% CI: 1.0005, 1.0064), wheezy chest (aOR: 1.0043; 95% CI: 1.0011, 1.0075) and COPD diagnosed on spirometry (aOR: 1.0100; 95% CI: 1.0014, 1.0190). The sensitivity test, excluding those with COPD who either had a previous history of tuberculosis or those with radiological evidence of tuberculosis, was also significantly associated with CEI (aOR: 1.0110; 95% CI: 1.00003, 1.0230).

We examined the potential negative effect of mine dump dust exposure on FEV1 and FVC using exposure groups and CEI as the exposure rubrics and percentage predicted spirometry values as the outcomes using multiple linear regression. We controlled for monthly income, pack-years of smoking, use of biomass fuels in the house and occupational exposure history to vapours, gas, dust and fumes. Table 6 shows that CEI was not significantly associated with FEV1 percent predicted (*p*-value=0.27). Counter-intuitively, a significant positive relation was found between CEI and FVC percent predicted: there was a 0.062% (*p*-value= 0.008) increase in the percentage of predicted FVC for every one-unit increase in CEI (after adjusting for potential confounders).

Discussion

This cross-sectional study of a community exposed to gold mine waste dump dust is the first to our knowledge to include chest radiographs and spirometry in the evaluation of respiratory health. The residents of Riverlea closest to the mine dump (high exposure group) and those with higher CEIs had higher risks of some respiratory and ocular symptoms, and, importantly, COPD diagnosed on spirometry. Multiple linear regression did not reveal exposure-associated lower percent predicted FVC and FEV1.

Symptoms

We found significantly elevated risks of upper respiratory tract symptoms and a wheezy chest associated with mine dust exposure, measured as either exposure group or CEI. Shortness of breath, chronic cough and chronic bronchitis were unrelated to the exposure. Two other South African studies have also reported an association between respiratory symptoms and exposure to gold mine dump dust. The first found a positive association between a wheezy chest (aOR: 1.38; 95% CI: 1.10-1.71) and rhino-conjunctivitis (aOR: 1.54; 95% CI: 1.29-1.82) compared to a community five kilometres away from a gold mine waste dump (Nkosi et al 2015a). The second studied Johannesburg residents 55 years or older living within 1-2 kilometres of a gold mine dump. They were found to be at higher risk of a wheezy chest (aOR = 2.01; 95% CI: 1.73-2.54) and chronic cough (aOR: 2.02; 95 % CI: 1.58-2.57) (Nkosi et al. 2015b) than subjects living 5 kilometres away (unexposed population).

We did not find significantly increased ORs for symptoms in the medium relative to the low exposure group in this study. These results tentatively suggest that the residents living within 500 metres of the gold mine waste dump may be at increased risk of these respiratory symptoms compared to other residents of the area.

In analyses adjusted for potential confounders we did not find exposure-associated significantly elevated risks of chronic bronchitis, although the adjusted relative effect estimates were > 1 for chronic bronchitis in the high relative to the low exposure group and in the CEI regression model. The lack of significant associations is contrary to that reported by Nkosi et al. (2015a)

who found elevated risks of chronic bronchitis in Johannesburg residents closer to the mine dump than those further away (aOR: 1.74; 95% CI: 1.26-2.39). Despite the lack of positive associations in our study, the subjects from Riverlea had high prevalences of chronic cough of 23.5% and chronic bronchitis of 12.8%, rising to 20.4% in the high exposure group, which exceeded the 14.3% in Ennerdale. These prevalences are similar to those reported by Nkosi et al. (2015a) at 26.6% and 13.4% in their exposed subjects, but much higher for chronic bronchitis (2.3% for men and 2.8% for women) identified in a general adult South African population survey published in 2004 (Ehrlich et al. 2004). The unexpectedly high prevalences of chronic cough (32.1%) and chronic bronchitis (14.3%) in Ennerdale may have obscured possible dust effects and are difficult to explain, although smoking probably contributed since 32% of the Ennerdale residents were current smokers. Ennerdale has no nearby sources of industrial pollution. The elevated, albeit not significantly so, ORs and the high prevalences of chronic cough and bronchitis in Riverlea means that we cannot exclude an effect of the mine dump dust on these conditions.

Silicosis

We found no cases of radiological silicosis in the Riverlea and Ennerdale communities. Environmental silicosis does occur following prolonged inhalation of desert sand dust (Norboo et al. 1991; Saiyed et al. 1991), but no studies have been published on silicosis in people exposed to wind-borne mine dump dust. According to a review on non-occupational silicosis, cases of silicosis have also been documented in communities close to slate pencil and agate industries (Bhagia 2012; Derbyshire 2007). The absence of silicosis in Riverlea residents may be because it does not occur in this population, or because it is relatively rare and our sample size was too small to identify it. Another explanation is that not enough of the Riverlea community had had sufficiently long exposure to develop the disease. This explanation is unlikely though, as 90% of the high exposure group had > 20 years' residence as had 57% of the medium exposure group.

Tuberculosis

Radiologically identified pulmonary tuberculosis prevalence did not increase consistently with exposure group, being highest in the medium group at 17.4%. This prevalence of pulmonary tuberculosis is higher than the prevalence of radiologically detected (old and new) tuberculosis (12.9%) in a low socioeconomic community in Cape Town, South Africa, which had the highest tuberculosis notification rate in the country (Den Boon et al. 2007). Self-reported tuberculosis was highest in Ennerdale: 7.1% versus 3.5% for Riverlea. Our methods of ascertaining tuberculosis have limitations: some misclassification of disease is likely using radiologic features; and unreliable recall may occur on questioning.

COPD

Our study identified a COPD prevalence of 18.6%, 10.2% and 10.4% in the high, medium and low exposure groups respectively, a combined prevalence for Riverlea of 13.7%. These values are lower than those of the Burden of Obstructive Lung Disease (BOLD) population-based survey done in Cape Town, South Africa, which found a prevalence of 23.8% (Buist et al. 2007). Of relevance is the high percentages of current smokers in the Cape Town survey: 56.9% in men; and 40.6% in women. We observed exposure-associated elevated risks for COPD in multivariate analyses adjusted for potential confounders using either exposure group or CEI as the exposure variable. The aOR for high vs low exposure groups was quite large at 8.17 (95% CI 1.01 -65.85). Other factors besides mine dump dust may explain these associations: the high exposure group smoked more, was less educated and earned less than their counterparts. These factors were adjusted for in multivariate analyses but there may have been residual confounding. A bigger study, preferably with more refined exposure data, is needed to confirm the association between mine dump dust and COPD.

Spirometry

Multiple linear regression showed no effect of CEI on FEV1 % predicted, but a counter-intuitive positive effect on FVC % predicted. We consider the latter effect to be spurious. We found no

literature on environmental dust exposure from mines or their waste dumps and effects on spirometric parameters of surrounding communities. However, the effect of ambient particulate matter more generally on lung function in adults has been investigated, producing inconsistent findings (Guo et al. 2018). Nevertheless, positive studies, particularly from Asia, have been reported recently showing a decline in FVC and FEV1 (Guo et al. 2018; Park et al. 2018) and an increase in COPD associated with elevated PM_{10} and $PM_{2.5}$ concentrations (Liu et al. 2017). A recent 2019 systematic review and meta-analysis done by Edginton et al. (2019), found evidence that long-term exposure to outdoor particulate air pollution is associated with decreased FEV1.

Limitations

Some limitations should be borne in mind when considering the results of this study. We did not have objective measures of exposure and the allocation to high and medium exposure groups may have been imprecise. Misclassification of exposure, therefore, possibly occurred for the Riverlea groups. This misclassification would obscure differences between the high and medium groups, assuming some medium exposed individuals should have been in the high exposure group. Recent objective measures of exposure could be misleading in any event as many of the participants had decades of residence in Riverlea and dust levels probably varied over time. Our exposure group classification based on distance from the mine dump has been used before in other studies (Nkosi et al. 2015a, 2015b). The other measure of exposure, the CEI, has not been used previously, but it has the potential to provide a more robust estimate of exposure since it is an amalgam of duration and intensity of exposure. Both these exposure estimates remain to be validated. Some dumps, but not those nearest to Riverlea, have been cleared and on-going clearing is taking place. The effect of this on the weighting we used is uncertain.

The somewhat disappointing uptake of spirometry and chest radiograph of about 50% may have meant that participants who had these investigations may not be representative of those interviewed. The potential effect of this is unclear; but possibly subjects with symptoms preferentially had the investigations resulting in artificially high prevalences of spirometric

abnormalities. This is unlikely, though, because there were no significant differences in the prevalences of chronic cough and dyspnoea among the respondents and non-respondents.

The use of the lower limit of normal of FEV1/FVC to define COPD may be a more reliable measure of the disease than the GOLD criterion of < 70%, since it takes account of an age-related decline in FEV1/FVC below 70%, thus reducing over-estimates of COPD in older people (Hardie et al. 2002; Miller et al. 2011). It does mean, though, that our COPD rates may not be comparable to those determined by the GOLD criterion.

Conclusion

This study showed that respiratory and ocular symptoms and objective measures of respiratory disease were higher in the most exposed group of study participants. Objective measurements of inhalable and respirable dust and respirable crystalline silica may help refine the use of distance of residence from mine dumps as an exposure tool and to improve the exposure weighting for calculating the CEI. Larger studies are required to explore the COPD mine dump dust exposure association found in this study.

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Figures



Figure 1: Map of the study area indicating the study sites and gold mine dumps (Source: Google Earth v 9.2.65.2, Johannesburg, Gauteng Province, South Africa. 26°08’45”S 28°16’08”E, Eye altitude 1 662m. Digital Globe 2012. http://www.earth.google.com [August 20, 2018])

Tables

Table 1. The definitions and data collection methods for the outcomes of interest.

Variables	Data collection method	Definition
Independent variables		
Cumulative exposure index	Study questionnaire	Derived using the quotient of number of years lived in an exposure group and the intensity weighting as determined by Ojelede et al. (2012)
Occupational history of exposure to vapours, gas, dust and fumes	Study questionnaire	Exposure for a year or more to vapours, gas, dust and/or fumes
Exposure to biomass fuels	Study questionnaire	The use of wood, coal and/or paraffin for either cooking or heating
Mean monthly household income	Study questionnaire	We used mean monthly household income as a proxy for socio-economic status
Smoking history	Study questionnaire	Positive history is at least one pack-year of smoking cigarettes in current or ex-smokers
Smoking pack-years	Study questionnaire	Number of cigarettes smoked per day divided by 20 and multiplied by the number of years of smoking
Dependent respiratory variables		
Upper respiratory tract symptoms	Study questionnaire	At least one of the following: rhinorrhoea, nasal congestion, oro-pharyngitis, a hoarse voice or chronic sneezing in the last two weeks without having the flu
Ocular symptoms	Study questionnaire	The presence of Itchy/watery eyes in the last two weeks
Lower respiratory tract symptoms		
Shortness of breath	Study questionnaire	Breathlessness walking up a slight hill
Chronic cough	Study questionnaire	A cough most days for 3 consecutive months or more during the year
Chronic bronchitis	Study questionnaire	Productive cough for at least three months in a year for at least two consecutive years
Wheezy chest	Study questionnaire	A wheezing or whistling chest in the last year

Self-reported diagnosis by a healthcare practitioner		
Emphysema or COPD	Study questionnaire	Diagnosed or treated by a nurse or a doctor
Asthma	Study questionnaire	Diagnosed or treated by a nurse or a doctor
Pulmonary tuberculosis	Study questionnaire	Diagnosed or treated by a nurse or a doctor
Objective findings of disease		
COPD on spirometry	Spirometry	FEV1/FVC ratio < lower limit of normal using the Global Lung Function Initiative (GLI) 2012 reference equations. Post-bronchodilator values were used for subjects with airflow limitation pre-bronchodilator.
Radiological evidence of probable tuberculosis	Chest X-ray	Typical signs of past or present tuberculosis such as presence of a focal infiltrate, cavity formation, hilar adenopathy, or a miliary pattern. A positive diagnosis required agreement by 2 of the 3 readers.
Radiological silicosis	Chest X-ray	Diagnosis based on the ILO International Classification of Radiographs of Pneumoconioses. Silicosis was defined as a profusion of 1/0 or more reported by at least two of the three readers.

Table 2. Characteristics and investigations of 310 study participants by exposure group.

Characteristics	Riverlea		Ennerdale
	High exposure	Medium exposure	Low exposure
	n=93 (%)	n=133 (%)	n=84 (%)
Median age in years (IQR)	49 (22-72)	53 (21-81)	46 (20-68)
	Range (18-81)	Range (18-88)	Range (19-73)
Sex			
Men	36 (38.7)	50 (37.6)	27 (32.1)
Women	57 (61.3)	83 (62.4)	56 (67.9)
Smoking history	60 (64.5)	58 (43.6)	39 (46.4)
Smoking pack-years			
Never smoked (<1 pack-year)	35 (37.6)	77 (57.9)	45 (53.6)
1-10	24 (25.8)	22 (16.5)	22 (26.2)
11-20	15 (16.3)	20 (15.0)	10 (11.9)
>20	19 (20.4)	14 (10.5)	7 (8.3)
Education			
None/Primary	21 (23.1)	14 (10.5)	10 (11.9)
Secondary	65 (71.4)	82 (61.7)	56 (66.7)
Tertiary	5 (5.5)	37 (27.8)	18 (21.4)
Monthly mean income for households			
<R1000	36 (39.6)	27 (20.3)	15 (17.9)
R1000-R5000	40 (43.9)	34 (25.6)	28 (33.3)
R5001-R9999	11 (12.1)	40 (30.10	25 (29.8)
≥R10000	4 (4.4)	32 (24.0)	16 (19.0)
Median years lived in exposure group (IQR)	38 (15-68)	20 (3-65)	16 (4-44)
	Range (2-76)	Range (1-80)	Range (2-61)
Reported dustiness outdoors during windy weather	85 (93.4)	119 (90.2)	75 (89.3)

Reported dustiness indoors during windy weather	58 (63.7)	86 (65.2)	55 (65.5)
Use of biomass fuels	3 (4.9)	24 (21.6)	20 (24.4)
House had an asbestos roof	65 (71.4)	39 (29.6)	1 (1.2)
Occupational history of exposure to vapour, gas, dust or fumes	49 (53.9)	37 (27.8)	15 (17.9)
No. of people who participated in chest X-rays	55 (59.1)	69 (51.9)	53 (63.1)
No. of people who participated in spirometry	43 (46.2)	59 (44.3)	47 (56.0)

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Table 3. Descriptive and univariate analysis with crude odds ratio and 95% confidence intervals of respiratory symptoms, self-reported respiratory conditions diagnosed by a healthcare practitioner (HCP) and objective findings of respiratory conditions by exposure group.

Variables	Riverlea		Ennerdale	Crude Odds Ratio (95% CI)		
	High exposure	Medium exposure	Low exposure	High vs low exposure	High vs medium exposure	Medium vs low exposure
	n=93 (%)	n=133 (%)	n=84 (%)			
Upper respiratory tract symptoms	63 (67.7)	59 (44.4)	34 (40.5)	**2.83 (1.58-5.08)**	**2.63 (1.52-4.58)**	1.17 (0.67-2.04)
Ocular symptoms	30 (32.3)	31 (23.3)	13 (15.5)	**2.63 (1.52-4.58)**	1.57 (0.87-2.83)	1.66 (0.81-3.39)
Shortness of breath	30 (32.6)	31 (23.5)	23 (27.4)	1.26 (0.66-2.41)	1.57 (0.87-2.83)	0.81 (0.43-1.51)
Chronic cough	32 (34.4)	21 (15.8)	27 (32.1)	1.11 (0.59-2.07)	**2.80 (1.49-5.27)**	0.40 (0.21-0.76)
Chronic bronchitis	19 (20.4)	10 (7.5)	12 (14.3)	1.54 (0.70-3.40)	**3.16 (1.39-7.16)**	0.49 (0.21-1.19)
Wheezy chest	40 (43.5)	28 (21.2)	16 (19.1)	**3.21 (1.62-6.34)**	**2.83 (1.58-5.08)**	1.13 (0.57-2.25)
Self-reported HCP[a] diagnosis of emphysema or COPD	8 (8.6)	10 (7.5)	7 (8.3)	1.03 (0.36-2.99)	1.16 (0.44-3.05)	0.89 (0.33-2.45)
Self-reported HCP diagnosis of asthma	8 (8.6)	10 (7.5)	7 (8.3)	1.03 (0.36-2.99)	1.16 (0.44-3.05)	0.89 (0.33-2.45)
Self-reported HCP diagnosis of TB[b]	4 (4.3)	4 (3.0)	6 (7.1)	0.58 (0.16-2.15)	1.45 (0.35-5.95)	0.40 (0.11-1.47)
	n=55	n=69	n=53			
Radiological evidence of probable TB	6 (10.9)	12 (17.4)	4 (7.5)	1.50 (0.40-5.65)	0.58 (0.20-1.67)	2.58 (0.78-8.51)
Evidence of silicosis on chest X-ray	0 (0)	0 (0)	0 (0)			
	n= 43	n=59	n=47			
COPD on spirometry	8 (18.6)	6 (10.2)	5 (10.6)	1.92 (0.58-6.40)	2.00 (0.67-5.95)	0.95 (0.27-3.33)

Median %FEV1 (IQR)	98 (59-121)	91 (48-110)	93 (75-120)	-	-	-
	Range (45-132)	Range (30-121)	Range (25-143)			
Median %FVC (IQR)	102 (71-134)	94 (60-117)	98 (79-119)	-	-	-
	Range (57-154)	Range (48-120)	Range (22-138)			

[a]HCP = Healthcare practitioner (nurse or doctor).

[b]TB = Tuberculosis.

Bolded values indicate significant results.

Table 4: Multivariate logistic regression models of the associations between exposure group and respiratory health outcomes with adjusted odds ratios and 95% confidence intervals.

	High vs low exposure	High vs medium exposure	Medium vs low exposure
Upper respiratory tract symptoms	**2.76 (1.28-5.97)**	**2.12 (1.01-4.42)**	1.31 (0.70-2.44)
Ocular symptoms	**4.68 (1.87-11.68)**	**3.01 (1.32-6.89)**	1.55 (0.70-3.43)
Shortness of breath	1.52 (0.67-3.44)	2.21 (0.997-4.91)	0.69 (0.34-1.39)
Chronic cough	0.80 (0.34-1.84)	2.18 (0.93-5.15)	**0.36 (0.17-0.77)**
Chronic bronchitis	1.76 (0.59-5.31)	**4.57 (1.35-15.48)**	0.39 (0.13-1.16)
Wheezy chest	**3.78 (1.60-8.96)**	**3.60 (1.60-8.11)**	1.05 (0.48-2.32)
Self-reported diagnosis of COPD or emphysema by HCP[a]	0.69 (0.17-2.78)	1.14 (0.28-4.71)	1.67 (0.51-5.46)
Self-reported diagnosis of asthma by HCP	0.73 (0.18-2.99)	0.96 (0.25-3.72)	0.77 (0.25-2.37)
Self-reported diagnosis of TB[b] by HCP	1.80 (0.33-9.81)	0.52 (0.12-2.18)	3.45 (0.83-14.41)
Radiological evidence of probable TB	1.86 (0.34-10.35)	0.46 (0.11-2.00)	4.03 (0.93-17.49)
COPD on spirometry	**8.17 (1.01-65.85)**	3.40 (0.59-19.62)	2.41 (0.37-15.54)

Note: All models adjusted for age, sex, monthly income, smoking pack-years, use of biomass fuels in the house, and occupational exposure to gases, fumes and dust. COPD diagnosed on spirometry was additionally adjusted for radiological features of tuberculosis on chest X-ray.

[a]HCP = Healthcare practitioner (nurse or doctor).

[b]TB = Tuberculosis.

Bolded values indicate significant result.

Table 5: Simple and multivariate logistic regression models of the associations between cumulative exposure intensity and respiratory health outcomes.

	Crude OR (95% CI)	aOR* (95% CI)
Upper respiratory tract symptoms	**1.0032 (1.0010-1.0053)**	**1.0034 (1.0005-1.0064)**
Ocular symptoms	**1.0028 (1.0005-1.0051)**	1.0031 (0.9999-1.0063)
Shortness of breath	**1.0029 (1.0006-1.0052)**	1.0027 (0.9996-1.0058)
Chronic cough	1.0009 (0.9986-1.0032)	0.9995 (0.9962-1.0027)
Chronic bronchitis	1.0025 (0.9996-1.0053)	1.0020 (0.9978-1.0062**)**
Wheezy chest	**1.0039 (1.0017-1.0062)**	**1.0043 (1.0011-1.0075)**
Self-reported diagnosis of COPD or emphysema by HCP[a]	1.0033 (0.9999-1.0067)	1.0017 (0.9963-1.0070)
Self-reported diagnosis of asthma by HCP	1.0020 (0.9985-1.0056)	0.9987 (0.9934-1.0039)
Self-reported diagnosis of TB[b] by HCP	1.0018 (0.9978-1.0059)	1.0005 (0.9949-1.0061)
Radiological evidence of probable TB	1.0019 (0.9978-1.0059)	1.0008 (0.9953-1.0065)
COPD on spirometry	1.0036 (0.9994-1.0078)	**1.0100 (1.0014-1.0190)**

Note: All models adjusted for age, sex, monthly income, smoking pack-years, use of biomass fuels in the house, and occupational exposure to gases, fumes and dust. COPD diagnosed on spirometry was additionally adjusted for radiological features of tuberculosis on chest X-ray.

[a]HCP = Healthcare practitioner (nurse or doctor).

[b]TB = Tuberculosis.

Bolded values indicate significant result.

Table 6: Multiple linear regression model of the FEV1 and FVC percent predicted on the cumulative exposure index.

Variables	**β**	**95% CI**	**p-value**
FEV1			
Cumulative Exposure Index (CEI)	0.029	-0.022-0.080	0.27
Interaction term			
smoking pack-years # CEI			
<1	Ref		
1-10	0.00014	-0.080-0.080	0.997
11-20	**-0.19**	**-0.30- (-0.077)**	**0.001**
>20	-0.040	-0.12-0.38	0.31
FVC			
Cumulative Exposure Index (CEI)	**0.062**	**0.016-0.11**	**0.008**
Interaction term			
smoking pack-years # CEI			
<1	Ref		
1-10	3.39e-06	-0.077-0.077	1.00
11-20	**-0.18**	**-0.27-(-0.093)**	**<0.001**
>20	-0.036	-0.13-0.054	0.43

Note: Model adjusted for monthly income, smoking pack-years, use of biomass fuels in the house, and occupational exposure to gases, fumes and dust. FEV1 $F < 0.001$, $R^2 = 0.31$. FVC $F < 0.001$, $R^2 = 0.31$.

Bolded values indicate significant result.

Appendix I: Plagiarism Declaration

I, **Samantha Iyaloo** (Student number: **1589948**) am a student registered for the degree of **Master of Medicine in the Speciality of Community Health (Occupational Medicine)** in the academic year **4**.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature:  Date: **20 October 2019**

Appendix I: Ethics Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Dr S Iyaloo
School of Public Health
Medical School
University

E-mail: Samantha.Iyaloo@nhls.ac.za

CC: Supervisor: Professor D Rees <David.Rees@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 18/05/2018

REF: *R14/49*

PROTOCOL NO: **M180493** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *Environmental dust exposure from gold mine dumps and chronic respiratory conditions*
Sub-study under M150550

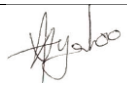
Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

Appendix III: Research Protocol

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

CANDIDATE'S SURNAME: **IYALOO** [Please print]	FIRST NAME/S: **SAMANTHA**	STUDENT NUMBER: **1589948**	
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DEGREE FOR WHICH PROTOCOL IS BEING SUBMITTED: **MMED (OCCUPATIONAL MEDICINE)**			
PART-TIME OR FULL-TIME: **FULL-TIME**			
FIRST REGISTERED FOR THIS DEGREE:	TERM : **1**	YEAR: **2016**	
DEPARTMENT: **DEPARTMENT OF PUBLIC HEALTH, OCCUPATIONAL HEALTH**			
TITLE OF PROPOSED RESEARCH: **Environmental Dust Exposure from Gold Mine Dumps and Chronic Respiratory Conditions**			
CANDIDATE'S SIGNATURE: 		DATE: 29/05/2017	
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SYNOPSIS OF RESEARCH

Introduction

In South Africa, mining processes from the Witwatersrand gold basin have resulted in approximately 270 mine dumps around Johannesburg, which are a significant source of air-borne dust. This dust consists of fine particulate matter (PM), which, when inhaled, may cause damage to the airways and lungs. Research in the Witwatersrand area has shown that environmental standards for inhalable particulate matter, often predominantly containing quartz, can be exceeded in the vicinity of mine dumps. Exposure to silica mine dusts may result in pulmonary fibrosis, chronic obstructive pulmonary disease (COPD), including chronic bronchitis and an increased prevalence of TB. Thus, dust rich in silica may result in restrictive, obstructive, or mixed patterns of impairment on pulmonary function testing. Mine dust is a hazard known to cause many respiratory conditions in exposed miners. There is however, no research on the long-term effects of this environmental exposure on residents living in close proximity to these mine dumps.

Objectives

- To determine the prevalence of respiratory symptoms and respiratory conditions shown in Table 1 by exposure intensity in the sampled Riverlea community in 2017, and
- To determine if there is an association in the sampled Riverlea residents between exposure to mine dust – expressed as likely exposure intensity strata (high, medium and low) and cumulative exposure index and respiratory symptoms, respiratory disease and lung function

Methodology

This secondary data analysis is a sub-set of a panel study- The Health, Environment and Development (HEAD) study, which is conducted annually by the Medical Research Council in the Riverlea community which is located in south-west Johannesburg. Riverlea is an old “apartheid-era” coloured community built around and in close proximity to established mines which have since become mine dumps. This cross-sectional study was a household community survey where an interviewer-administered questionnaire was conducted on a single member of the household. An amended HEAD study questionnaire was used to capture the information required (see Appendix B). Following written informed consent, participants completed a questionnaire administered by the interviewer covering: demographic information, residential history, occupational and domestic exposures and information on potential confounders, respiratory symptoms and physician-diagnosed disease. Spirometry was conducted using methods described in ATS/ERS 2005 Standardisation of Lung Function Testing standards and COPD and asthma will be sought. Chest X-rays will be assessed for signs of previous PTB and silicosis will be sought and graded according to the ILO International Classification of Radiograph of Pneumoconioses.

Data Analysis

Descriptive statistics such as frequency tables will be used to describe the independent variables within the exposure intensity strata (low, medium and high exposure). Socio-demographic data, respiratory symptoms (especially on dusty days) and self-reported physician-diagnosed respiratory diseases will be presented. The following socio-demographic variables will be presented: age category, sex, occupational category, number of years residing in Riverlea, level of education, smoking history, use of biomass fuels, and heat source during winter. Stata 14 (Stata Corporation, College Park, Texas, USA) will be used for data analysis. Log-binomial regression and simple linear regression will be done using the outcome described in Table 1.

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Environmental Dust Exposure from Gold Mine Dumps and Chronic Respiratory Conditions

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1. INTRODUCTION

1.1. Background

Gold mine tailings commonly referred to as mine dumps lie in very close proximity to some residential areas in the Witwatersrand. Residents of these areas may be at increased risk of respiratory conditions resulting from wind-blown exposure to airborne particulate matter, especially gold mine dust rich in crystalline silica (1). In the Witwatersrand, inhalable dust which is rich in quartz (the common form of crystalline silica) has been shown to exceed exposure standards (2). Mine dumps, besides containing high silica content, also contain heavy metals and other toxic materials such as radioactive uranium and cyanide (2,3). Dust originating from mine dumps can be wind-blown to large distances (2). Furthermore, predictive simulations have demonstrated that residents in close proximity to the mine dumps are at risk of exposure to respirable and inhalable mine dust (2).

There is not much research on respiratory health effects especially those objectively measured by chest radiology and lung function tests that aims to determine the relationship between these health effects and environmental exposure to silica-rich dust emanating from gold mines dumps. In particular, there is no research on the long-term effects of this environmental exposure on residents living in close proximity to these mine dumps.

Riverlea is a long-established township in south west Johannesburg surrounded by gold mine dumps. It is thus a location to investigate exposure from these dumps and chronic respiratory health effects. Additionally, Riverlea is the site of a larger study entitled The Johannesburg Health, Environment and Development (HEAD) study, a longitudinal study conducted by the Medical Research Council (MRC), which collects household information on demographics, socio-economic and health factors. The MRC study provides a framework to conduct a study on mine dump exposure and respiratory health effects. This MMed proposal describes the use of secondary data obtained from the HEAD study, to investigate exposure to gold mine dump dust and chronic respiratory health effects in residents of Riverlea.

1.2. Summary of the Literature

1.2.1. Exposure

In South Africa, mining processes from the Witwatersrand gold basin have resulted in approximately 270 mine dumps around Johannesburg, which are a significant source of air-borne dust (4,5). This dust

consists of fine particulate matter (PM), which, when inhaled, may cause damage to the airways and lungs (6). Research in the Witwatersrand area has shown that environmental standards for inhalable particulate matter, often predominantly containing quartz, can be exceeded in the vicinity of mine dumps (7). Particulate matter and quartz dust have been shown to travel up to two kilometres downwind of mine dumps and may affect up to half a million people who live in and around these dumps (2). In a study by Triveldi et al, it was shown that dust generated from mining activities, does not negatively affect ambient air quality with normal weather conditions in areas more than 500 meters from the mine (8). It can thus be seen from these studies that although dust could travel for large distances, it may be that only exposure within 500 m or so of the dust generation is likely to result in exposure which may cause respiratory conditions.

1.2.2. Health effects

Air pollution exposure from mine waste dumps is variable and dependent on pollutant emissions and on weather conditions. There is evidence demonstrating that this variation corresponds with exacerbations of respiratory symptoms (2,5,9,10). Deterioration in lung function and chronic respiratory conditions are less well demonstrated. Chronic obstructive pulmonary disease (COPD), asthma and lung diseases due to inhaled agents are among the most common chronic respiratory conditions (11). Chronic respiratory conditions are an important group of diseases of public health concern due to their considerable morbidity and mortality, their high socio-economic burden and because they are largely preventable (1,2,3). Exposure to silica mine dusts may result in pulmonary fibrosis, chronic obstructive pulmonary disease (COPD) and chronic bronchitis (15). Thus, dust rich in silica may result in restrictive, obstructive, or mixed patterns of impairment on pulmonary function testing (16).

Chronic bronchitis

Chronic bronchitis is usually defined on history as a cough with phlegm production most days for at least 3 months of the years for two consecutive years (17). A combination of risk factors are shown to be responsible for chronic bronchitis including occupational exposures, exposure to biomass fuels, smoking and tuberculosis (TB) (17). A study in the Netherlands describing the disability-adjusted-life-years associated with chronic bronchitis due to long-term environmental exposure in 4 085 adults was 1 920 years (18). In a South African study, the prevalence of chronic bronchitis within 1-2 km of a mine dump was 13.4% compared to a prevalence of 7.5% in a population >5 km from a mine dump,

demonstrating that chronic bronchitis was positively associated with close proximity of mine dumps compared to resident who lived further away from mine dumps (10).

COPD

COPD is currently the fourth and is projected to be the third leading cause of death by 2020 worldwide due to its increasing prevalence (19,20). COPD is characterised by persistent airflow limitation and a chronic inflammatory response to noxious particles in the airways and the lung (21). COPD has a number of aetiologies the most important being the cumulative exposure to noxious gases and particles including silica, airway hyper-responsiveness and a number of host factors (11). The most important causes which we will consider as confounders in this study are smoking, occupational exposures and use of biomass fuels in the household. COPD can be reasonably reliably diagnosed using simple lung function tests of dynamic ventilation (spirometry) and applying the widely used diagnostic criteria published by the Global Initiative for Chronic Obstructive Lung disease (GOLD). The presence of a post-bronchodilator forced expiratory volume in one second (FEV1) <80% of the predicted value in combination with an FEV1/FVC <70% confirms the presence of airflow limitation that is not fully reversible (20). Furthermore, the lower limit of normal (LLN) of the FEV1/FVC ratio which will be calculated using pre-determined Global Lung Function Initiative (GLI) 2012 reference equations for the 5th percentile of a healthy, non-smoking population is usually used. The GOLD classification has an age-related bias which tends to over-estimate COPD in older people, therefore newer studies use the LLN as a cut-point for obstructive lung function rather than 70% of FEV1/FVC (22–24).

A subset of the global Burden of Obstructive Lung Disease (BOLD) study which focused on the prevalence of COPD in adult never smokers >40 years found a prevalence of 12.2% of people with GOLD stage I or higher (25). The population attributable risk for smoking and COPD varies from 40-70% depending on high or middle/low income countries respectively (26). In a 2003 systematic review of COPD occupational risk factors, demonstrated that approximately 15% of all COPD cases may be attributable to workplace exposures such as toxic gases, dust and fumes in mines and factories and grain dust from farms (9). Biomass fuels are a biological substance derived from a plant or animal source e.g. crop residues, wood, animal dung, vegetable matter and charcoal (27). It is an inefficient combustible energy source which may result in high concentrations of substances that are harmful to health (27). Although silica dust is an accepted cause of COPD (11), the condition has not been studied using spirometry in people living in close proximity to mine dumps.

Silicosis

Silicosis is caused by exposure to silica mine dust (28). The basic pathology of silicosis is interstitial fibrosis. It is usually detected on chest X-rays which show the presence of small opacities in the lung fields. It is usually an occupational lung disease, but can be caused by environmental exposures (29). The profusion and shape/size of opacities are conventionally quantified on a 12 point grading system referred to as the International Labour Organisation (ILO) International Classification of Radiographs of Pneumoconioses (30). In epidemiologic studies two or three readers classify the chest X-ray changes and the median read is used to describe the radiologic features. There are no published studies on silicosis in people living in proximity to gold mine dumps.

Pulmonary tuberculosis (PTB)

Past infection with Mycobacterium tuberculosis in community-based studies is usually assessed by self-reported history and radiologic changes consistent with past TB (31). There have been a few studies done in Tanzania, India and Latium region that demonstrate environmental silica dust exposure increases the risk for developing pulmonary TB (28,32,33). There have however, not been any studies in our high TB prevalence country examining the association between TB and exposure in communities near mine dumps.

Reduced lung function

Lung function in population-based studies is typically assessed by tests of forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) expressed as percentages of predicted values standardised for height, weight, age, and gender.

The Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) found that air pollution especially exposure to particulate matter 10 micrometres or less in diameter (PM10), was associated with a decline in forced expiratory volume in one second (FEV1) (34). Another study also found that an increase in PM10 exposure is associated with a decline in lung function especially seen reflecting small airway function (35). A 2014 population-based cohort study in England, however, found limited and inconclusive evidence for associations between outdoor air pollution and COPD (36). The effect of exposure to mine dump dust and reduced lung function is thus uncertain.

1.3. Justification for Research

There is currently very little research on respiratory health effects in communities around mine dumps, especially using objective measures of health outcomes like spirometry and chest X-rays. The Riverlea community is aware of the exposures and is concerned about possible respiratory health effects of

exposure to wind-swept dust from the surrounding mine dumps and have thus expressed a desire for research on this issue. Although research including questionnaires on respiratory symptoms and physician-diagnosed disease, has been conducted within the Riverlea community, no objective measure of disease was used. The addition of investigations in the form of chest X-rays and spirometry in this community will establish near-accurate prevalence estimates for chronic respiratory diseases and reduced lung function in relation to dust exposure. It is envisioned that undiagnosed cases of chronic respiratory disease will be detected and thus study participants where a respiratory disease is diagnosed, will be referred to the appropriate medical structures for treatment.

2. AIMS AND OBJECTIVES

2.1. Aim

The aim of this research is to analyse the data obtained from the HEAD study and to determine if there is an association between exposure to quartz-rich mine dump dust, respiratory symptoms and objectively measured respiratory disorders in the residents of Riverlea, Johannesburg.

2.2. Objectives

- To determine the prevalence of respiratory symptoms and respiratory conditions shown in Table 1 by exposure intensity in the sampled Riverlea community in 2017, and
- To determine if there is an association in the sampled Riverlea residents between exposure to mine dust – expressed as likely exposure intensity strata (high, medium and low) and cumulative exposure index and respiratory symptoms, respiratory disease and lung function.

3. METHODOLOGY

3.1. Study Design

This cross-sectional study is a sub-set of a panel study- The Health, Environment and Development (HEAD) study which is conducted annually in the Riverlea community. The HEAD study is described in Appendix A. This study is a secondary data analysis of a sub-set of the data obtained during the HEAD study. The HEAD study was a cross-sectional study of a household community survey where an interviewer-administered questionnaire was conducted on a single member of the household. Residents who have not met the inclusion criteria or those who have an exclusion criterion will not be included in this study.

3.2. Study Setting and Study Population

The HEAD study was conducted in the Riverlea area, located in south-west Johannesburg. Riverlea is primarily an old "apartheid-era" coloured community built around and in close proximity to established mines which have since become mine dumps (located on the east, south and west of Riverlea) (37). According to the 2011 census, Riverlea has a total population of 16 226 individuals and approximately 4 208 households (Statistics South Africa, 2012). The study included men and women ≥35 years who have resided within the Riverlea area for ≥15 years. Households have been pre-selected randomly and are currently partaking in the HEAD panel study. The study enrolled participants over three weeks in July 2017. Households were randomly identified using a table of random numbers and town planning maps of the study areas. The HEAD study collects information on all the members of a household; however, our sub-study and secondary data analysis will focus on a single member of the household. This will preferably be the respondent. Information collected by the respondent on the selected member will be telephonically verified with the selected participant.

3.3. Study Procedure

This MMed research is a secondary data analysis on the respiratory health effects which was collected as part of the larger HEAD study. Previously selected houses participating in the HEAD longitudinal study were approached by an interviewer for enrolment into this sub-study. See Figure 1 for the study process.

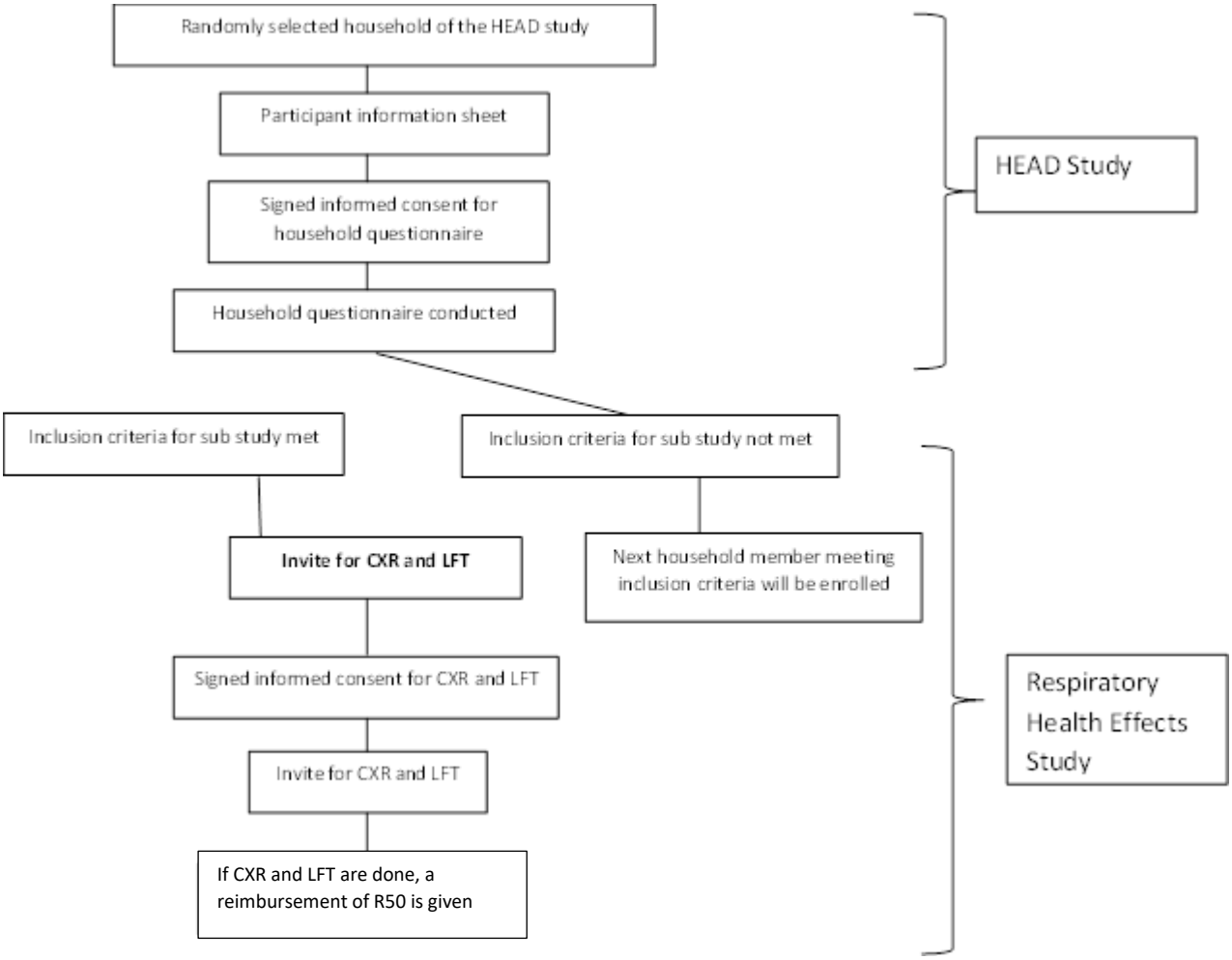


Figure 1: Flow diagram of study process and enrolment

3.4. Measurement Tools

3.4.1. Questionnaire

An amended HEAD study questionnaire was used to capture the information required (see Appendix B). Following written informed consent, participants completed a questionnaire administered by the interviewer covering: demographic information, residential history, occupational and domestic exposures and information on potential confounders, respiratory symptoms and physician-diagnosed diseases. Interviews were conducted by environmental health students from the University of Johannesburg and nurses from the National Institute for Occupational Health who were trained in interviewing techniques, the study questionnaire and fieldwork processes. The questionnaire was conducted in English which is one of the languages common in the Riverlea area. Participants with respiratory diseases had a detailed exposure history taken by an occupational medicine specialist. The majority assessment of a panel of three experienced occupational medicine specialists will be used to determine whether the disease has another cause more likely than environmental dust exposure. The

participant will be referred to the appropriate healthcare facility with the chest X-ray report, lung function and a referral note from the occupational medicine specialist.

3.4.2. Spirometry

Spirometry will be conducted by experienced, accredited, trained service providers using methods described in ATS/ERS 2005 Standardisation of Lung Function Testing standards (38). The lung function tests will be reviewed by an occupational medicine specialist trained and proficient in using the criteria depicted in figure 1. If there is an FEV1/FVC ratio <70% and/or a FEV1 <80% of predicted, a bronchodilator will be administered to identify reversible airway disease.

3.4.3. Chest Radiographs

Chest X-rays will be assessed for signs of previous PTB such as fibrotic changes and cavities in the upper lobes. Silicosis will be sought and graded according to the ILO International Classification of Radiographs of Pneumoconioses. Two occupational medical specialists with training and experience in the interpretation of radiological signs of PTB and pneumoconiosis using the ILO International Classification of Radiographs of Pneumoconioses system will be used to report these features independently. If there is disagreement among them regarding the radiologic features, a third trained reader will report and the median of the three reads will be used. Pneumoconiosis will be defined as a profusion of opacities 1/0 or greater.

3.5. Outcome Definitions

COPD will be defined by using the traditional GOLD criteria for COPD and using the lower limit of normal (LLN) of the FEV1/FVC ratio which will be calculated using pre-determined Global Lung Function Initiative (GLI) 2012 reference equations for the 5th percentile of a healthy, non-smoking population (39). Figure 2 shows the algorithm for diagnosing common outcomes and Table 1 summarises other outcomes and their assessment measures.

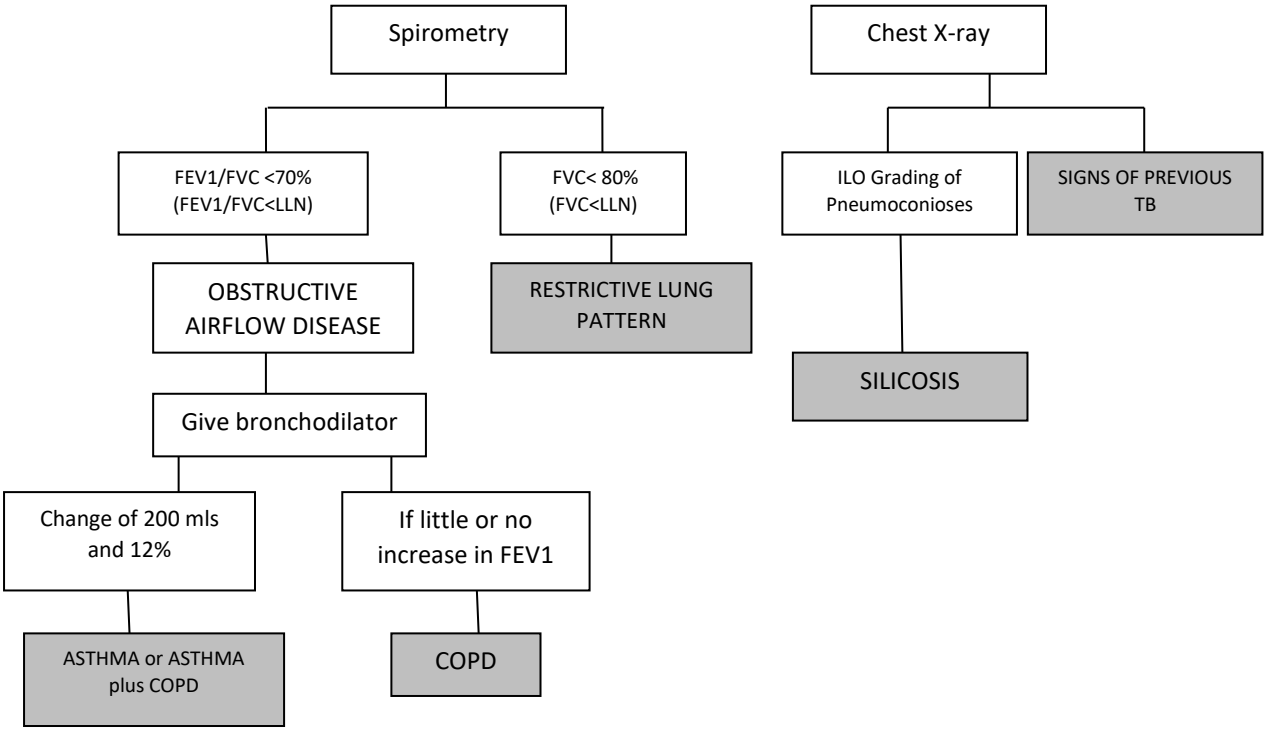


Figure 2: Spirometry and chest X-ray algorithm to diagnose COPD, asthma and restrictive lung pattern, silicosis and signs of previous TB

Table 7: Outcomes of Interest Environmental Dust Exposure from Gold Mine Dumps and Chronic Respiratory Conditions

Outcome	Diagnostic method	Comment
Lung function (continuous outcome)	Spirometry	Both FVC and FEV1 will be examined using % of predicted of GLI 2012 reference (prediction) equations.
Tuberculosis (binary outcome)	History and chest x-ray	On chest X-ray, typical signs of past or present TB will be sought such as fibrosis and apical cavities.
Asthma (binary outcome)	History and spirometry	History = symptoms consistent with asthma and/or history of doctor diagnosed asthma
Dust-exacerbated asthma (binary outcome)	History and spirometry	
Chronic bronchitis (binary outcome)	History	Usual definition of productive cough for at least 3 months in a year for at least two consecutive years.

Chronic obstructive pulmonary disease (COPD) (binary outcome)	Spirometry	
Pneumoconiosis (binary outcome)	Chest X-ray	Diagnosis based on the ILO International Classification of Radiographs of Pneumoconioses

3.6. Inclusion and Exclusion Criteria

3.6.1. Inclusion Criteria

Resident's ≥ 35 years, who have stayed in the Riverlea area for ≥15 years, were eligible for enrolment into the study. The residents may have resided elsewhere initially and then moved to Riverlea or they may have grown up in Riverlea and then left the area and subsequently returned, as long as their total residential time in Riverlea ≥15 years.

3.6.2. Exclusion Criteria

Residents unable to give consent and/or unwilling to have chest X-rays and lung function tests done on them were excluded from the study. Pregnant female patients were excluded due to the hazard of radiation exposure to the foetus or developing embryo and also due to decreased lung function measurement of pregnant women in advanced pregnancy.

3.7. Exposure metrics

3.7.1. Exposure intensity

Distance of the house from the nearest mine waste dump border will be used as one measure for exposure in Riverlea. This will be done by using a map with the Riverlea extensions and demarcated areas including the mine dumps around Riverlea. Additionally, Riverlea residents will be graded into three exposure intensities: those from Extension One which is the area of Riverlea closest to the mine dump will be classified as high exposure. The furthest part of Riverlea from the mine dump is Riverlea Extension Three. This will be called a low exposure area. Riverlea Proper is the area between Riverlea Extension One and Three, and this will be classified as medium exposure.

3.7.2. Cumulative exposure index (CEI)

A CEI will be derived for each participant using the product of years of residence and intensity of exposure. Numerical values for exposure intensity will be High exposure = 4; Moderate exposure = 2

and Low exposure =1 as detailed by Sunyer et al (40). CEI for participants with > 1 category of exposure intensity will be derived using the formula CEI = [(residence 1 intensity x duration 1) + residence 2 intensity x duration 2) + (residence i intensity x duration i intensity)].

3.8. Sample Size

Given that the prevalence of COPD in South Africa ranged from 7.3% (25) to 24.8% (41) in the general population, a sample size of 216 was calculated to detect a 12% difference in the prevalence of COPD across the exposure intensity groups (high, medium and low exposure), with sufficient power (80%) and 95% confidence, while allowing for 10% non-response rate. Therefore 80 households from each pre-specified exposure intensity stratum in Riverlea were enrolled.

3.9. Data Management

Quantitative data from the questionnaire were collected electronically on low cost smart phones or tablets preloaded with the questionnaires using the Mobenzi application. Once data is recorded on the phone/ tablet it will be downloaded into spread sheets which will then be imported into Stata Statistical Package. All analyses will be conducted using Stata 14 software (StataCorp LP College Station, Tx). Mobenzi Research provides a secure web application for building and managing databases online. The Medical Research Council is one of the institutional partners of Mobenzi. Mobenzi Research has a range of in-built, quality, logical and consistency checks which will aid in data validity and completeness. Data will also be checked manually for completeness by the principal investigator. Queries will be opened and addressed with the appropriate interviewer and closed when the appropriate alteration has been made. All records will be archived on the Mobenzi server for at least five years after completion of the study. Stata 14 software (StatacOrp LP College Station, Tx) will be used for inconsistencies such as missing values and duplicates using Stata commands such as “summarize, list, edit and duplicate”.

3.10. Data Analysis

Descriptive statistics such as frequency tables will be used to describe the independent variables within the exposure intensity strata (low, medium and high exposure). Socio-demographic data, respiratory symptoms (especially on dusty days) and self-reported physician-diagnosed respiratory diseases will be presented. The following socio-demographic variables will be presented: age category, sex,

occupational category, number of years residing in Riverlea, level of education, smoking history, use of biomass fuels, and heat source during winter. Stata 14 (Stata Corporation, College Park, Texas, USA) will be used for data analysis.

3.10.1. Objective 1

The prevalence of respiratory symptoms and respiratory conditions will be calculated for each exposure intensity stratum. The respiratory conditions that will be considered are shown in Table 1. Chi-square tests or Fisher's exact tests will be used as appropriate for categorical data to determine if there are any significant differences between the exposure intensity groups. A P-value of <0.05 will be used as the pre-determined significance level. See Appendix C for Dummy Table 1. These analyses will be repeated using tertiles of CEI as the exposure metric.

3.10.1. Objective 2

Testing associations between exposure and respiratory outcomes

Two exposure variables will be used: exposure intensity (high, medium and low); and CEI. The former is categorical and the latter continuous. The respiratory outcomes are binary (i.e. yes/no) except for lung function as measured by FEV1 and FVC, which are continuous.

Crude associations, binary outcomes

Crude, unadjusted associations between exposure and binary outcomes (see Table 1) will be estimated using prevalence ratios and their 95% confidence intervals (42). Separate analyses will be done for exposure intensity and tertiles of CEI.

Crude associations, continuous outcomes

Crude, unadjusted associations between exposure and lung function will be estimated using simple linear regression. Lung function will be the percentage of predicted which is standardised for sex, age, ethnicity and height. CEI as a continuous variable will be used in these analyses.

Multivariate analyses, binary variables

Adjusted prevalence ratios will be estimated using log binomial regression. The independent variables entered into the regression model will be those associated with the dependant variable in the univariate analyses at a $p \leq 0.2$. Exposure will be CEI.

Multivariate analyses, continuous variables

Adjusted associations between exposure and lung function will be estimated using multiple linear regression. The exposure metric will be CEI. The lung function measures will be percentage of predicted, transformed if not normally distributed.

Confounders

Confounding may be important in TB, chronic bronchitis, COPD and lung function. For the latter three conditions, education (as a surrogate for SES), occupational exposures, use of biomass fuels and smoking will be considered as potential confounders. For TB education, diabetes, smoking, age and occupational silica exposure will be considered.

4. ETHICAL CONSIDERATIONS

4.1. Protection of Human Participants

If any participant is found to have lung disease of possible occupational or environmental origin (e.g. silicosis), they will be asked to visit the Occupational Medicine Clinic at the National Institute for Occupational Health for a more detailed assessment by an occupational medicine physician. Other non-occupational diseases detected upon special investigation will be referred using the existing medical referral structures.

4.2. Participant Information Sheet and Informed Consent

Ethics approval of the entire HEAD study which included the sub-set was obtained from the University of the Witwatersrand Human Research Ethics Committee (M150550). Information regarding the study will be relayed to the potential participant (see Appendix D). Written informed consent to conduct the household questionnaire (Appendix E) available in English and Afrikaans was sought. Written informed consent to conduct the household questionnaire was sought. Participants of the HEAD study who met the inclusion criteria for the chest X-rays and lung function tests will be asked to sign separate informed consent for the chest X-ray and lung function test before it is conducted. See Figure 1 for the study process flow chart which includes the consent process. Informed consent leaflets were translated in Afrikaans which is the most common vernacular language of the residents of Riverlea. Participants who are unable to read or write were asked to make a mark or thumbprint in the presence of a witness. Separate informed consent was obtained for the chest X-ray and lung function tests and all the dangers of both were explained to the potential participant (see Appendix F). Another separate permission and disclaimer will be obtained from women of reproductive age so that the study team make sure that

there are no pregnant females and that they understand the risks if they are potentially pregnant (Appendix G).

4.3. Regulatory Approval

Approval will be sought from the Human Research Ethics Committee (Medical) (HREC) of the University of the Witwatersrand (WITS) for this sub-set which includes a secondary data analysis. Ethics approval of the entire HEAD study which included the sub-set was obtained from the University of the Witwatersrand Human Research Ethics Committee (M150550).

4.4. Confidentiality

All study records will be managed in a secure and confidential manner. All data records will be stored on a secure system managed by Mobenzi and access will be restricted to specified study team members. Data records will be de-identified and a study participant number will be allocated. The questionnaire, lung function and CXR will be linked by a unique code that only the primary researcher manages and has access to.

5. STUDY LIMITATIONS

Cross-sectional studies only measure the prevalence of an outcome of interest at a specific time. This type of study is therefore weak at establishing temporality. This study has many confounders which we are aware of and will aim to adjust for but there may however be other less important factors which could confound the relationship between exposure and outcome. These may be nutritional and health status during childhood, genetic predispositions, inadequate housing structure to prevent entry of the dust into the home, recurrent excessive exposure to the dust from the mine dumps (children playing on the mine dumps daily) and exposures to heavy metal dusts among others. The residents of Riverlea are exposed to a number of other environmental exposures which are problematic but which are not addressed in this proposed research.

Exposure misclassification is not possible because objective measures of dustiness will be available. The effect of this bias is difficult to estimate but it may drive effect estimates to the null if the misclassification is non-differential. Physician diagnosed respiratory disease may under-estimate the

true burden of disease and patients when asked about symptomatology may over-estimate or exaggerate the burden of symptoms experienced. Thus, the major benefit and strength of this study is that it aims to accurately identify cases of COPD, asthma, silicosis and previous TB on spirometry and chest X-ray. All X-rays will be reviewed by two independent medically trained doctors who have undergone recent training in the ILO International Classification of Radiographs of Pneumoconioses.

6. LOGISTICS AND TIMELINES

The secondary data analysis of the respiratory health effects sub-section of the larger HEAD study will be led by the study PI, Dr Samantha Iyaloo (Occupational Medicine Registrar-NIOH) and Professor David Rees (Occupational Medicine Specialist-NIOH). This includes conducting the chest X-rays and lung function tests. Dr Iyaloo was also involved in the amendment of the HEAD study questionnaire so that it addresses the respiratory symptoms disease. Dr Iyaloo has a certificate in Good Clinical Practice and will be primarily responsible for the over-sight of the study. This study will be aided by the HEAD study conducted by the Medical Research Council and led by Dr Nisha Naicker. See Appendix H for the timelines.

7. PUBLICATIONS AND INFORMATION SHARING

The research findings will be presented to national/ local stakeholders (including the Riverlea community and the mining companies). The results will be written up as one or more articles for submission to a suitable scientific journal. A component of this study, will contribute to a MMed project in Occupational Medicine (Dr Samantha Iyaloo).

8. BUDGET AND RESOURCES

This study fulfils one of the core objectives for completion of the MMed programme in Occupational Medicine. Thus, funding will be available through the National Institute for Occupational Health (NIOH). The NIOH covers the monthly salary for the principal investigator. Office equipment, telephones, computer, software, printer, transport and IT support is available at the NIOH. See Appendix I for the budget.

9. CONCLUSION

This study will add value to the current literature on environmental causes of chronic respiratory disease. A study that aims to objectively measure lung disease in a dust exposed community by

conducting lung function tests and chest X-rays has never been done in South Africa according to our knowledge. The findings from this research will aim to address the residents' concerns and make recommendations for the betterment and upliftment of the community.

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APPENDIX A: THE HEALTH, ENVIRONMENT & DEVELOPMENT (HEAD) STUDY

The HEAD study is an initiative of the partners of the World Health Organization Collaborating Centre for Urban Health. The overall goal of the study is to build research and environmental health capacity amongst environmental health students of the University of Johannesburg, public health students of the University of the Witwatersrand and environmental health staff of the City of Johannesburg. As part of their experiential learning, environmental health students at the University of Johannesburg are trained in the research process, interviewing and interview techniques and conduct the fieldwork for the HEAD study. From the analysis of the data, suggestions for Masters and Doctorate level studies are provided to the Universities of Johannesburg and the Witwatersrand and staff of the City of Johannesburg.

The objective of the HAD study is to monitor change in housing conditions and health status in five Johannesburg settlements. A Panel Study is being conducted in the settlements of:

1. Hillbrow - a high-rise, densely populated inner city area in central Johannesburg;

2. Bertrams - a mixed development, inner city suburb that has been undergoing a process of degradation over the past two decades, but is now earmarked for rapid development in the run-up to the World Cup soccer tournament in 2010;

3. Riverlea (Extension 1) - an impoverished, degraded apartheid-era township to the south-west of the City;

4. Braamfischerville - a relatively new housing development initiated under the umbrella of the Reconstruction and Development Programme;

5. Sweetwater and Hospital Hill - two informal settlements to the west of Johannesburg.

Phase (Year) One of the HEAD study was undertaken in August/September 2005, when representatives of 581 households in the five settlements were interviewed. Information was collected in respect of:

◦ Socio-economic status;

◦ Migration patterns;

◦ Health and injury status;

◦ Mental health;

◦ Perceptions of neighbourhood infrastructure.

The main findings of the HEAD study can be made available.

APPENDIX B: ADDENDUM TO THE HEAD STUDY QUESTIONNAIRE

Outcome of interview	
Completed questionnaire	
Partially completed questionnaire *Reason:*	
Questionnaire not started *Reason:*	
Samples can be collected (soil, dust wipe	
Agree	
Disagree	
Other	
vegetable seeds accepted	
Vegetable garden in yard	

THE HEAD STUDY QUESTIONNAIRE

Year of Study	2	0	1	6

STICK ADDRESS HERE

Interview date	D	D	M	M	2	0	1	6

Name of Interviewer

Respondent's name		
Telephone/ Cell number:		
Sex of respondent	Male	Female
Was the respondent interviewed last year for the same study	Yes	No

Guidelines for interviewers:
*All options or comments in italics **MUST NOT BE READ** out to the respondents.*

A. DEMOGRAPHY & SOCIO-ECONOMIC STATUS

1.	**a. In which country were you born?**	1 South Africa 2 Other, **Specify** _____	☐
	b. If born in South Africa, in which PROVINCE were you born?	1 Eastern Cape 2 Free State 3 Gauteng 4 Kwa-Zulu Natal 5 Limpopo 6 Mpumalanga 7 Northern Cape 8 North West 9 Western Cape	☐
2.	**How many people live on this plot (within the boundaries of the yard)?**		☐
3.	**a. How many separate households live on this plot?** *(Definition of a household: a group of people who usually eat together)*		☐
	b. Are all households	1 Part of the same family 2 People who rent part of the dwelling?	☐
Interviewers: unless otherwise specified, the remaining questions refer to the main household			
4.	**How many people, including you, make up this (main) household?**		☐
5.	**How many children under five years of age are part of this household?** *(If no children, state 0)*		☐
6.	**What is the main language spoken in this household?** **(Please choose one)**	1 Afrikaans 2 English 3 Ndebele 4 Sepedi 5 Sesotho 6 Setswana 7 Swati 8 Tsonga 9 Venda 10 Xhosa 11 Zulu 12 Other: _____	☐
7.	**How long has this household been living in this dwelling?**	Months Years	☐ ☐

Starting with the respondent please state the first name, age, sex, educational qualification for each member of the household. If RESPONDENT is also the HEAD OF HOUSEHOLD leave P2 blank.

Interviewers: after the respondent and/or the head of the household, list residents from oldest to youngest. Person 1(P1) remains P1, P2 remains P2 .... throughout the questionnaire.

8.	***Name / ID code***	***Age (years)***	***Sex***		**Achieved educational qualification** *(state '5' - Not applicable for children not of school going age)*	
8.1	**Person 1/P1 (Respondent) Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary [redacted]	
8.2	**Person 2/P2 (Head of household) Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary [redacted]	
8.3	**Person 3/P3 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.4	**Person 4/P4 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.5	**Person 5/P5 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.6	**Person 6/P6 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.7	**Person 7/P7 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.8	**Person 8/P8 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.9	**Person 9/P9 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	
8.10	**Person 10/P10 Name:**		0 Male 1 Female		1 None 2 Primary 3 Secondary 4 Tertiary 5 Not applicable	

Starting with the respondent please state the main weekly activity for each member of the household.

Interviewer: If RESPONDENT is also the HEAD OF HOUSEHOLD leave P2 blank.

Interviewers: after the respondent and/or the head of the household, list residents from oldest to youngest. Person 1(P1) remains P1, P2 remains P2 .... throughout the questionnaire.

9.	***Name / ID code***	***Main weekly activity***			***Please specify type of job, tertiary subject studied or school grade achieved where applicable***
9.1	**Person 1/P1** (Respondent) **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School [redacted] 9 Other _____	☐	
9.2	**Person 2/P2** **Name:** (Head of household)	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School [redacted] 9 Other _____	☐	
9.3	**Person 3/P3** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.4	**Person 4/P4** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.5	**Person 5/P5** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.6	**Person 6/P6** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.7	**Person 7/P7** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.8	**Person 8/P8** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.9	**Person 9/P9** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	
9.10	**Person 10/P10** **Name:**	1 Full time job 2 Part time job 3 Unemployed 4 Housewife / husband 5 Informal job	6 Tertiary education 7 School 8 Crèche 9 Other _____	☐	

10.	**What is the average monthly income for this household - excluding grants & pensions?**	1 No income	
		2 < R1000	
		3 R1001 – R5000	
		4 R5001 – R10000	
		5 >R10000	
11.	**How many people in the household receive the following grants?** *Please fill in appropriate numbers.*	1 Old age grant/pension	
		2 Disability grant	
		3 Child support grant	
		4 Other, specify _____	
12.	**How much money (in Rands) does this household spend on the following items every month?** *Please fill in appropriate amounts. If respondents can only remember annual amounts divide this figure by 12.*	**1. Food**	R
		2. Transport (include taxi fare, petrol, car instalment)	R
		3. Housing- rent, bond etc	R
		4. Water	R
		5. Electricity	R
		6. Paraffin	R
		7. Coal	R
		8. Wood	R
		9. Gas	R
		10. Other type of fuel: Specify	R
		11. Alcohol	R
		12. Cigarettes	R
		13. Entertainment (such as cinemas, nightclubs, attending sporting events, theatre)	R
		14. Telephones & Cellular Telephones	R
		15. Medical expenses (include transport to clinics, medication etc)	R
		16. Schooling/University (including uniforms, books, fees etc)	R
		18. Debt repayments	R
13.	**Does anyone in this household have medical aid?**	**1=Yes** **0=No**	

14.	**Please state whether members of this household OWN any of the items (in working order)**	1. Radio **1=Yes 0=No**	
		2. Television **1=Yes 0=No**	
		3. Satellite television (e.g. DSTV or M-Net) **1=Yes 0=No**	
		4. Refrigerator **1=Yes 0=No**	
		5. Washing machine **1=Yes 0=No**	
		6. Video/DVD machine **1=Yes 0=No**	
		7. Microwave **1=Yes 0=No**	
		8. Car **1=Yes 0=No**	
		9. Computer **1=Yes 0=No**	
		10. Telephone (landline) **1=Yes 0=No**	
		11. Cellular phone (plain) **1=Yes 0=No**	
		12. Cellular smart phone **1=Yes 0=No**	
		13. IPAD or Tablets **1=Yes 0=No**	
		14. Internet service **1=Yes 0=No**	
15.	**Does anyone in this household have any money saved in a bank, building society or stokvel?**	**1=Yes 0=No**	☐
16.	**Is the owner of this house a:** ***(Please choose one)***	0 Male 1 Female 2 Male and Female (dual ownership) 3 Not applicable (do not own house)	☐
17.	**Is the person who makes most decisions in this household a:** ***(Please choose one)***	0 Male 1 Female 2 Male and Female (joint decision-making)	☐
18.	**Does anyone regularly do any of the following at home for extra money?** ***(Please choose one)***	1. Fix cars **1=Yes 0=No**	
		2. Spray painting of cars **1=Yes 0=No**	
		3. Make metal jewelry **1=Yes 0=No**	
		4. Welding **1=Yes 0=No**	
		5. Fix electrical appliances **1=Yes 0=No**	
		6. Scrap metal recycling **1=Yes 0=No**	
		7. Hairdressing **1=Yes 0=No**	
		8. Other activity at home **1=Yes 0=No** Specify:	

B. HOUSING and NEIGHBOURHOOD

19.	INTERVIEWER: *Please record the type of dwelling used by the main household. (Please choose one)*	1 Formal house built by professional builder 2 Formal house that was self-built 3 Informal dwelling 4 Backyard dwelling-formal 5 Backyard dwelling-informal 6 Flat 7 Business premises used for accommodation 8 Other, specify _____	☐
20.	**Approximately how old is the house?**	In years	☐
21.	**How many separate rooms are there in this dwelling/house?** *Please fill in the number of each room*	Kitchen (for cooking only) Bathrooms / toilets Dining rooms Lounge Bedrooms	
22.	**How would you describe the following issues in this dwelling?**		
	1. Peeling paint (indoors)	1=No problem 2=Moderate problem 3=Major problem	
	2. Peeling paint (outdoors)	1=No problem 2=Moderate problem 3=Major problem	
	3. Cracks in walls	1=No problem 2=Moderate problem 3=Major problem	
	4. Ventilation (a good supply of fresh air)	1=No problem 2=Moderate problem 3=Major problem	
	5. Lighting	1=No problem 2=Moderate problem 3=Major problem	
	6. Windows broken	1=No problem 2=Moderate problem 3=Major problem	
	7. Leaks in roof	1=No problem 2=Moderate problem 3=Major problem	
	8. Leaking water pipes in or around the dwelling	1=No problem 2=Moderate problem 3=Major problem	
	9. Fungus or mould on walls or ceilings	1=No problem 2=Moderate problem 3=Major problem	
	10. Odours (bad smells) in the area	1=No problem 2=Moderate problem 3=Major problem	
	11. Overcrowding in the dwelling	1=No problem 2=Moderate problem 3=Major problem	
	12. Overcrowding in other dwellings in the area	1=No problem 2=Moderate problem 3=Major problem	
	13 Air pollution in the neighbourhood	1=No problem 2=Moderate problem 3=Major problem	

	14. Waste collection in your neighbourhood.	1=No problem 2=Moderate problem 3=Major problem	
23.	**During windy weather, does the air get very dusty/sandy in this area?**	**1=Yes** **0=No**	
24.	**If yes, where do you think the dust/sand comes from?**		
25.	**Is dust inside the dwelling a major problem?**	**1=Yes 0=No**	
26.	**What do you <u>mainly</u> use to dust the house?** ***Please choose one option only.***	1 A feather duster 2 A dry cloth 3 A dry cloth with furniture polish 4 A damp cloth 5 A cloth soaked in soapy water 6 Other (please specify)_____	
27.	**What do you mainly use to clean the floors of the house?** ***Please choose more than one if necessary.***	A dry broom to sweep **1=Yes 0=No** A mop with water only **1=Yes 0=No** A mop with soapy water **1=Yes 0=No** Vacuum cleaner **1=Yes 0=No** Other (please specify) **1=Yes 0=No** _____	
28.	**How often do you clean the floors?** ***(choose one option)***	1 Daily 2 More than once a week 3 Once a week 4 More than once a month 5 Seldom	
29.	**Is there dampness in the building?** ***If yes go to q30, if no go to q32***	**1=Yes 0=No**	
30.	**Where is the dampness in this building found?**	Kitchen **1=Yes 0=No** Bathrooms / toilets **1=Yes 0=No** Dining rooms **1=Yes 0=No** Lounge **1=Yes 0=No** Bedrooms **1=Yes 0=No**	
31.	**What do you think has caused the dampness?** ***(e.g. plumbing leak, drying clothes, cold house, rising dampness, rotten window frames)***		
32.	**Is there mould (fuzzy woolly spots) in the dwelling?** ***If yes go to q33 if no skip to q39***	**1=Yes 0=No**	
33.	**In which room/s is the mould?**	Kitchen **1=Yes 0=No** Bathrooms / toilets **1=Yes 0=No** Dining rooms **1=Yes 0=No**	

		Lounge 1=Yes 0=No	
		Bedrooms 1=Yes 0=No	
34.	**What colour is the mould?**		
35.	**Have you tried to clean the mould?** *If no, skip to 37*	**1=Yes 0=No**	
36.	**How often do you clean the mould?** *Please choose one option only*	1 Whenever you notice it 2 Every week 3 Every month 4 Seldom	
37.	**Has mould growth been noted on the following surfaces?** *Choose all that apply*	Brick walls 1=Yes 0=No Dry wall 1=Yes 0=No Wooden walls 1=Yes 0=No Wall-papered walls 1=Yes 0=No Carpets 1=Yes 0=No Wooden skirting 1=Yes 0=No Ceilings 1=Yes 0=No Tiles 1=Yes 0=No Shower or bath 1=Yes 0=No Curtains 1=Yes 0=No Cupboards 1=Yes 0=No Window frames 1=Yes 0=No Furniture 1=Yes 0=No Clothes 1=Yes 0=No	
38.	**Do you dry clothes indoors?**	**1=Yes 0=No**	
39.	**What do you use mainly for cooking?** *(Please choose one)*	1 Electricity 2 Paraffin 3 Gas 4 Wood 5 Coal 6 Other: specify	
40.	**What do you use mainly for indoor heating?** *(Please choose one)*	1 Electricity 2 Paraffin 3 Gas 4 Wood 5 Coal 6 Imbhawula 7 Other: specify	
41.	**What do you use mainly for heating water?** *(Please choose one)*	1 Electricity 2 Paraffin 3 Gas	

		4 Wood	
		5 Coal	
		6 Other: specify	
42.	**Do you receive free basic electricity**	**1=Yes 0=No**	
43.	**Are any pets or animals kept inside the house?** **If yes, please specify type of pet**	**1=Yes 0=No** _____	
44.	**Does anyone in the household smoke?**	Cigarettes **1=Yes 0=No**	
		Pipe tobacco **1=Yes 0=No**	
		Hookah / Hubbly bubbly **1=Yes 0=No**	
		Electronic cigarettes **1=Yes 0=No**	
		Other: specify_____ **1=Yes 0=No** _____	
45.	**How many of the people living in this household smoke inside the dwelling?** **List the person number of all who smoke?**	***Number of people*** P , P , P , P ,P	
46.	**Does anyone in this household own a Hookah pipe?**	**1=Yes 0=No**	
47.	**What is the age of the youngest person who smokes the Hookah?**	***(Age in years)***	
48.	**Do you think that a Hookah can harm your health?**	**1=Yes 0=No**	
49.	**Do you think that a Hookah is good for your health?**	**1=Yes 0=No**	

C. HEALTH

49.	*Name*	a. **Acute symptoms:** In the past 2 weeks have you or anyone in your household experienced the following *(please circle Y=yes or N= no)*				b. If yes, did you seek medical treatment?	c. *Where did you go for treatment?*	
49.1	Person 1/P1	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.2	Person 2/P2	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.3	Person 3/P3	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.4	Person 4/P4	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.5	Person 5/P5	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			

		6 Earache	Y N					
49.6	Person 6/P6	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.7	Person 7/P7	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.8	Person 8/P8	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.9	Person 9/P9	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					
49.10	Person 10/P10	1 Wet cough	Y N	7 Headaches	Y N	1 Yes 0 No	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify	
		2 Dry cough	Y N	8 Rapid breathing	Y N			
		3 Runny / blocked nose	Y N	9 Sore throat	Y N			
		4 Fever and chills	Y N	10 Sneezing	Y N			
		5 Chest pain	Y N	11 Teary watery eyes	Y N			
		6 Earache	Y N					

50.	Has anyone in the household ever had wheezing or whistling in the chest?						
	Name	*Wheezing any time in past?*	*Wheezing in last 12 months?*	*Number of attacks in last 12 months? (choose one option)*	*Did you seek medical treatment?*	*Where did you go for treatment? (choose one option)*	*Has anyone been diagnosed with asthma?*
		Yes =1 No=0	Yes =1 No=0	1 None 2 1 to 3 3 4 to 12 4 > 12	Yes =1 No=0	1 Clinic 2 Doctor 3 Traditional healer 4 Self-medicated 5 Other, specify _____	Yes =1 No=0
	Person 1/P1						
	Person 2/P2						
	Person 3/P3						
	Person 4/P4						
	Person 5/P5						
	Person 6/P6						
	Person 7/P7						
	Person 8/P8						
	Person 9/P9						
	Person 10/P10						

51.	*Information on skin rashes*						
	Name	Have you ever had an itchy rash which was coming and going for at least 6 months?	Have you had this rash at any time in the last 12 months?	Has this rash at any time affected the following places? *(may choose more than one option)*	At what age did this itchy rash first occur?	Has this rash cleared completely at any time in the past 12 months?	Has anyone been diagnosed with asthma
		Yes =1 No=0	Yes =1 No=0	1 Folds of elbow 2 Behind knees 3 In front of ankles 4 Under buttocks 5 Around neck, ears or eyes	*Age in Years*	Yes =1 No=0	Yes =1 No=0
	Person 1/P1						
	Person 2/P2						
	Person 3/P3						
	Person 4/P4						
	Person 5/P5						
	Person 6/P6						
	Person 7/P7						
	Person 8/P8						
	Person 9/P9						
	Person 10/P10						

52.	**Have you EVER been diagnosed or treated for the following conditions by a medical doctor or the clinic nurse?** (Anytime in the past)									
		Bronchitis		Pneumonia		*Emphysema*		*Tuberculosis*		*Chest operation/ procedure*	
	Person 1/P1 **(Respondent)**	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 2/P2 **(Head of household)**	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 3/P3	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 4/P4	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 5/P5	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 6/P6	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 7/P7	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 8/P8	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 9/P9	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 10/P10	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	

53. Have you or anyone in your household been diagnosed with the following illnesses?

53.	*Name / ID code*	*Cancer*		*Diabetes*		*Hypertension*		*Heart disease*		*Stroke*		*HIV/AIDS*		*Obesity*		*Mental illness*		*Disability*	
	Person 1/P1 (Respondent)	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 2/P2	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 3/P3	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 4/P4	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 5/P5	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 6/P6	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 7/P7	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 8/P8	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 9/P9	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	
	Person 10/P10	1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No		1 Yes 2 No	

54. **Has anyone in this dwelling died in the past 12 months?**	**Yes = 1** **No = 0**	
If yes, how old was s/he?	**:years**	**:months**
If yes, state sex	**Male =0** **Female =1**	
What did s/he die from?		

55.	*Mental health questions (SRQ 20) (Interviewer please read out the following paragraphs)*			
	The following questions are related to certain pains and problems that may have bothered you in the last 30 days. If you think the question applies to you and you had the listed problem in the last 30 days, answer YES. On the other hand, if the question does not apply to you and you did not have the problem in the last 30 days, answer NO. **Please do not discuss the following questions with anyone while answering. If you are unsure about how to answer a question, please give the best answer you can.** **We would like to reassure you that the answers you are going to provide here are confidential.**			
	1	Do you often have headaches?	Yes	No
	2	Is your appetite poor?	Yes	No
	3	Do you sleep badly?	Yes	No
	4	Are you easily frightened?	Yes	No
	5	Do your hands shake?	Yes	No
	6	Do you feel nervous, tense or worried?	Yes	No
	7	Is your digestion poor?	Yes	No
	8	Do you have trouble thinking clearly?	Yes	No
	9	Do you feel unhappy?	Yes	No
	10	Do you cry more than usual?	Yes	No
	11	Do you find it difficult to enjoy your daily activities?	Yes	No
	12	Do you find it difficult to make decisions?	Yes	No
	13	Is your daily work suffering?	Yes	No
	14	Are you unable to play a useful part in life?	Yes	No
	15	Have you lost interest in things?	Yes	No
	16	Do you feel that you are a worthless person?	Yes	No
	17	Has the thought of ending your life been on your mind?	Yes	No
	18	Do you feel tired all the time?	Yes	No
	19	Do you have uncomfortable feelings in your stomach?	Yes	No
	20	Are you tired easily?	Yes	No
		Total number of yes answers		
56.	**In the past month have any of the children in this household had to miss school/crèche due to illness?**		**1=Yes 0=No**	
57.	**Has anyone's income in this household been affected by illness in the last 6 months?**		**1=Yes 0=No**	

D. GENERAL INFORMATION

58.	**What do you like least about living in this neighbourhood?**
59.	**What do you like most about living in this neighbourhood?**
60.	**What is the WORST thing that happened to this household in the past year (July 2015-July 2016)?**
61.	**What is the BEST thing that happened to this household in the past year (July 2015-July 2016)?**

THANK YOU FOR TAKING THE TIME TO ANSWER THIS QUESTIONNAIRE.

WITH YOUR PERMISSION, MAY WE RETURN TO ASK YOU MORE QUESTIONS? | **Yes** | **No** |

IF YES, please give us your Contact number _____

FOR INTERVIEWER/S

I declare that I have asked this entire questionnaire as it is laid out and as I have been briefed.

The questionnaire has been fully checked by me.

PLEASE PRINT

	Student 1	**Student 2**
First name		
Surname		
Signature		
Student Number		
Date		

FOR SUPERVISOR / OFFICE USE ONLY

Name of Supervisor		**Date checked (dd/mm/yy)**	
Questionnaire checked	**Yes** **No**	**Comment:**	
Dust wipe collection checked	**Time checked:**		
	Floor wipe	**Yes**	**No**
Soil sample checked	**Soil**	**Yes**	**No**
Evaluation of the interviewers	**Student 1**		
	Student 2		
Supervisor signature			

APPENDIX C: DUMMY TABLES

Dummy Table 1: Prevalence of symptoms and disease comparing the different dust exposure intensity in residents of Riverlea, 2017

	Low exposure N=100	**Medium exposure N=100**	**High exposure N=100**	**p-value**
Self-reported physician-diagnosed disease	n/N (%)	n/N (%)	n/N (%)	
Dust-exacerbated asthma				
COPD				
Previous TB				
Upper respiratory symptoms	n/N (%)	n/N (%)	n/N (%)	
Chronic sinusitis				
Chronic rhinitis				
Pterygium				
Red/itchy/watery eyes				
Hoarse voice				
Lower respiratory symptoms	n/N (%)	n/N (%)	n/N (%)	
Chronic and productive cough				
Shortness of breathe				
Wheezing				
Chest pain with breathing				
Conditions determined by CXR and LFT	n/N (%)	n/N (%)	n/N (%)	
TB				
Asthma				
COPD				
Pneumoconiosis				

Dummy Table 8: Univariate and multivariable log-binomial regression comparing residents with COPD with independent variables in the residents of Riverlea, 2017

		Univariate log-binomial regression		Multivariable log-binomial regression	
	n/N (%)	RR (95% CI)	p-value	aRR (95% CI)	p-value
Age (years) 35-45 46-65 >65					
Gender Male, n/N (%)					
Number of years n Riverlea					

Dust exposure levels Low exposure Medium exposure High exposure					
Smoking (yes/no)					
Use of biomass fuels in house					
Work in dusty environment					
Self-reported physician-diagnosed disease					
COPD					
Asthma					
Previous TB					
Upper respiratory symptoms					
Chronic sinusitis					
Chronic rhinitis					
Pterygium					
Red/itchy/watery eyes					
Hoarse voice					
Lower respiratory symptoms					
Chronic bronchitis					
Shortness of breathe					
Wheezing					
Chest pain with breathing					

Dummy Table 9: Multiple Linear Regression analysis of percentage predicted FEV1

Independent variable	**Regression Coefficient**	**t-statistic**	**P-value**
Intercept			
Age (years)			
Gender			
Smoking pack years			
Work in a dusty environment			
Use of biomass fuels			
Previous history of TB			

APPENDIX D: PARTICIPANT INFORMATION SHEET

THE JOHANNESBURG HEALTH, ENVIRONMENT AND DEVELOPMENT (HEAD) PROJECT

Dear Participant

Introduction:

I am from the Medical Research Council, the University of Johannesburg and the National Institute for Occupational Health. We are conducting a study on housing and health in your neighbourhood and would be grateful if you could assist us to fill out a questionnaire. Specifically, we wish to interview you about your environment and well-being. The interviewer may also ask you to reveal any health problems you or your family have experienced. This study takes place every year in July/August. Therefore you may have been interviewed in previous years.

Invitation to participate:

We are asking you to take part in this investigation.

What is involved in the study?

If you agree to participate you will be interviewed by students from the University of Johannesburg or Nurses from the Medical Research Council. The interview should take between 20-30 minutes. This may cause you some inconvenience by taking you away from your normal daily activities.

You or another pre-selected member of the household will be invited to have a chest X-ray and a breath test done at another date that suits you. Both these tests will be able to tell us if you have a lung condition. The location of both these tests will be at the local Riverlea Recreational Centre in Colorado Street. You will be reimbursed a set amount of R50 for your taxi fare to reach the Recreational Centre after both tests are done.

After the interview, in a few houses included in the study, a second team of investigators may take samples from the surfaces in your home and will ask you a few additional questions. These samples will be sent to a laboratory to look for evidence of dust that can affect your health. The team will return to your home to provide feedback and answer any questions you may have at a later date.

Risks:

There are no risks anticipated in the study but if discomfort is experienced in answering a question you do not have to answer. You are also free to withdraw your participation at any point during the process (without having to give reasons).

All X-rays pose a risk of developing cancer if many X-rays are done in the course of your life. Exposure from a single X-ray is unlikely to cause any problems. The breath test may cause some discomfort but this test is easy to perform and you are just asked to breathe deeply in and out.

Benefits:

The information you provide us with today will be used to assess changes that are occurring in your community. The researchers unfortunately will not be able to change or make improvements to the environment you live in. The information obtained from the study each year will be submitted to the City of Johannesburg and other stakeholders (community leaders) who may be able to assist the community.

The chest X-ray and breathe test that you or another family member will perform will help diagnose if you have any chest-related problem. The report of the chest X-ray and breath test will be given to for your benefit. If there is an abnormal result you will be referred to a health facility for further review. These tests are usually expensive to perform, so doing them will confirm if you have any lung condition and will help you to get treatment you may require quicker.

Participation is voluntary:

To be able to participate, you have to sign a form saying that you give us permission to do so. If you do not want to participate, nothing will happen. You may also discontinue participation in the study at any time without giving reasons and without penalty or loss of any benefits.

Confidentiality:

We will make every effort to keep personal information confidential. Personal information will only be disclosed if required by law. When the interviews are completed, the forms containing your personal information will be kept separately in a locked cupboard at the Medical Research Council. The results of this study will be published, but the names of participants will not be given to anyone. The study findings will be reported to the Department of Health and other relevant policy makers.

If you have any queries, please do not hesitate to contact:
Dr Nisha Naicker, Medical Research Council, Environment & Health Research Unit, PO Box 87373, Houghton, 2041, Tel: 082 059 5756, Email: nisha.naicker@mrc.ac.za

Participants can contact the Wits ethics committee if they have queries or problems:

Tel (011) 7171234

APPENDIX E: STUDY CONSENT FORM

Participant's Name:	
Contact telephone number:	
Study identification number:	
Date of birth	

I……

(Participant's Name)

hereby agree to participate in the Health Environment And Development study undertaken by the Medical Research Council.

The research objectives have been explained to me and I understand that I will be interviewed on issues regarding my home and neighbourhood and my and my family's health.

I have been informed that everything I say in this interview will be confidential; my name will not be attached to what I say. So nobody will know what I said. The information will be used for research purposes only.

I acknowledge that the results of this research project may be published in medical and scientific journals; however, my name will not be mentioned. The results will be reported only as a group. Separate permission will be obtained for the chest X-ray and breath test.

I understand that my participation is voluntary, and that I am free to withdraw from the project at any time without giving any reasons.

I agree to allow researchers to return to my home to take samples, if my home is selected.

Signature: ……. Date:_____/_____/17

INTERVIEWERS, IF THE RESPONDENT IS UNCOMFORTABLE WITH WRITING, PLEASE OBTAIN VERBAL CONSENT AND SIGN ON THEIR BEHALF BELOW.

I, _____(name of interviewer), certify that I have explained the information sheet to the research participant, who has given verbal approval to participate in the HEAD study.

Signed: _____ Date:_____/_____/17

APPENDIX F: INFORMED CONSENT FOR CXR AND LFT

ENROLMENT NUMBER: 01- ☐☐☐☐ **STUDY NUMBER: 02-** ☐☐☐☐

I, _____ (name of participant), acknowledge that the process for enrolment into the study and the study questionnaire have all been explained to me and that I agree for myself to participate in the following study procedures:

☐ Y☐ N I agree to be interviewed regarding the study questionnaire.

☐ Y☐ N I agree have a lung function test and chest X-ray done on me

The signature of the participant below means that the study has been explained and that he/ she agrees to participate.

Name of participant:

Signature of participant:

Date:

The signature of the witness below means that another person has observed the consenting of the parent or legal guardian.

***Name of witness**:*

***Designation**:*

***Signature of witness**:*

***Date**:*

APPENDIX G: INFORMED CONSENT FOR CHEST X-RAY FOR WOMEN OF REPRODUCTIVE AGE

X-Ray Consent

ENROLMENT NUMBER: 01- ☐☐☐☐ **STUDY NUMBER: 02-** ☐☐☐☐

Patient Name: _____

Patient DOB: _____

PLEASE ANSWER THE FOLLOWING QUESTIONS: FEMALE ONLY

Are you pregnant or any chance you may be: _____ YES _____ NO

The exam your doctor has ordered uses Ionizing radiation which can have a severe health effect during pregnancy to an unborn baby. The possibility of severe health effects depends on the gestational age of the unborn baby at the time of exposure and the amount of radiation it is exposed to. Unborn babies are particularly sensitive to radiation during their early development, between weeks 2 and 15 of pregnancy. Such consequences can include stunted growth, deformities, abnormal brain function, or cancer that may develop sometime later in life. You should contact your doctor if you believe you may be pregnant to discuss possible side effects and the risks and benefits of the procedure. If you feel that you may be pregnant, please inform the radiologic technologist before your exam.

_____ To the best of my knowledge I am not pregnant or believe there is any possibility that I may be pregnant.

_____ I know or believe that I may be pregnant and fully understand the risk and health effects radiation may cause to my

Patient signature: _____ Date: _____

APPENDIX H: TIMELINES

		MONTH											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
ACTIVITY	**RESPONSIBILITY**												
1. Protocol development	Investigators												
2. Ethics approvals	Investigators												
3. Protocol edits and permissions	Investigators												
4. Study team recruitment and training	PI												
5. Recruitment of patients for study a. Screening b. Informed consent c. Questionnaire d. Special investigation	On-site study team												
6. Preliminary data analysis (1 year of data)	PI												
7. Data analysis & presentation	PI												

APPENDIX I: PROPOSED BUDGET

ACTIVITIES	DESCRIPTION	UNIT COST (R)	TOTAL COST (R)
Part 1			
Respiratory Effects (Riverlea)	Mobile Lung function tests (x 300) **(extra budget for additional houses)**	120.00	36 000.00
	Mobile CXR (x300)	240.00	72 000.00
	Transport reimbursement for the residents (round trip x 300)	50.00	15 000.00
	Enrolled/profession nurse fieldworkers for additional questionnaires for 10 week days@ 8 hours/day (x6)	16 000.00	64 000.00
	Data	500.00	500.00
	Airtime	500.00	500.00
	Mobenzi data management costs	5 000.00	5 000.00
	Administrative costs (printing, scanning, stationery, etc)	2 000	2 000
Total			**195 000**

Appendix IV: Environmental Health Perspectives Author Guidelines

GENERAL GUIDELINES

A few requirements apply to all manuscript types; those requirements are listed below. See the sidebar for more detailed information on preparing specific article types.

General Guidance

All manuscripts should be as concise as possible without sacrificing information necessary for reproducibility and clarity. Failure to comply with author instructions may result in a delay of the manuscript handling and review process.

EHP covers all disciplines engaged in the broad field of environmental health science. Therefore, write in a clear and simple manner; when possible, use active rather than passive voice to avoid ambiguity. Avoid unnecessary jargon, and define terms that may not be universally recognized among all environmental health scientists.

Line Numbering

Enable continuous line numbering on all manuscripts (i.e., line numbers should NOT restart at 1 on each page). Manuscripts received without continuous line numbers will be returned to the author for revision before peer review.

Title Page

Include the following items in the order shown, beginning on the first page of the manuscript:

- Manuscript title
- Names of the authors, with the first name provided first
- Affiliations of all authors (department, institution, city, state/province, and country)
- Complete contact information for the corresponding author (name, email address, and postal address)
- Declaration of competing financial interests (CFI)

Symbols and Equations

Use MathType or Word's Equation Builder tool to generate mathematical expressions and equations, as well as any equation variables used within the text itself.

- Place simple expressions and equations in line. Present in-line equations on one line, and do not stack fractions. Example:

Average air concentration (C_{air}) was derived using $C_{air} = M_{pas}/(R_{PUF-PAS} \times t)$.

- Place complex expressions and equations, including those with stacked fractions, on a separate line, and include a number in brackets (on the same line, to the right) if needed. Example:

$$CD = \left(\frac{100 \times C_B^Y}{E_{50}^Y + C_B^Y} \right) \qquad [1]$$

- Define all nonstandard elements, including superscripts and subscripts.
- Use bold text to represent vectors.
- Ensure that all symbols and equations are correctly displayed when viewed on a monitor and in print.

Footnotes

Do not use footnotes in the main manuscript text. Place all textual information within the manuscript, and indicate all references as in-text citations and, if applicable, as entries in the list of references.

RESEARCH ARTICLES

Research articles report original research results that are relevant to the relationship between the environment and human health, and that make a substantial advance in the field. For research articles involving animal subjects, authors must adhere to the ARRIVE (Animals in Research: Reporting *in Vivo* Experiments) guidelines for reporting animal research (Kilkenny et al. 2010; Tilson and Schroeder 2013). For observational research studies, *EHP* strongly recommends that authors consult an appropriate version of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Suggested Length

Suggested length is < 7,000 words, excluding the text in the abstract, references, tables, figure legends, acknowledgments, and Supplemental Material.

Title

The title should consist of ≤ 300 characters and should state the subject of the paper and include relevant information to help potential readers determine whether the paper might be related to their interests or needs. Relevant information includes the exposure(s) and outcome(s) assessed, and whether the study was observational or experimental. For epidemiological studies, consider key characteristics of the study population (e.g., gender, age, location, cohort) and design. For experimental studies, indicate the experimental model, including species or *in vitro* system(s). The title should not be a declarative statement of the study results or conclusions.

Abstract

Include a structured abstract of ≤ 300 words using the following headings: Background, Objectives, Methods, Results, Discussion.

The abstract should not include references or any information that does not appear in the text of the manuscript. We recommend that authors indicate study names or sources of data that are integral to the study. Summarize major findings in a balanced manner, rather than focusing only on findings that support the study hypothesis.

Main Text Structure

Sections should appear in the following order:

- Introduction
- Methods
- Results
- Discussion
- References
- Tables
- Figure legends

Concise subheadings (≤ 8 words each) may be used to designate major topics within each of these sections. Subheadings should be used to organize information, but should not summarize or interpret results or conclusions. Do not exceed three levels of headings, including the main headers.

Introduction

Provide background information to support the motivation for the study, and state the study objectives or hypotheses. Specifically,

- Provide context for the study, including information on the exposures and outcomes and why they are relevant to environmental health.
- Briefly review the literature to summarize current knowledge.
    - Indicate whether the research was observational or experimental, and note key characteristics of study populations or experimental models.
    - Present a balanced review of the literature, and acknowledge inconsistencies, rather than noting only findings that support the present study hypothesis.
- Identify knowledge gaps addressed by the current study.
- Provide a clear description of the study questions/hypotheses, aims, or objectives, and, if appropriate, an overview of the approach used to address them.

Do not summarize study results or conclusions in the Introduction.

Methods

EHP requires complete methodological transparency—describe methods in enough detail to ensure that the study could be repeated by other researchers in the same field (at least in theory), and that it can be understood and interpreted by most *EHP* readers. Specifically,

- Thoroughly describe the methods used to generate all results reported in the manuscript, including (as appropriate):
    - Study design and population or experimental model
    - Methods to measure or estimate exposures
    - Outcome definitions and ascertainment or measurement
    - Assay methods and conditions
    - Justification of exposure and/or doses
    - Number of biological and/or technical replicates
    - Statistical analyses
    - Accession numbers (or “rs” numbers for SNPs)
    - Sensitivity and secondary analyses
    - All criteria used to interpret results
    - Key assumptions and limitations of the methods
    - Model numbers of all equipment used
    - Company name, catalog number, and lot numbers for all reagents used
    - Names/version numbers for data analysis software packages or macros
- If referring to previous publications for methods details, include a brief description of the approach, key assumptions and limitations, and any deviations from previously described methods.
- Do not report results unless relevant to explain the rationale for the approaches listed.

For research that involves animals, include all relevant details listed in the latest version of the ARRIVE guidelines, and indicate that the protocol was approved by an institutional animal care and use committee. Provide a rationale for the doses used, and indicate how they compare with environmental exposures experienced by humans.

For research that involves human subjects, include all relevant details listed in an appropriate version

of the STROBE or other guidelines. Provide information about institutional review board approval, and either describe informed consent protocols or explain why informed consent was not required.

Results

Report all results on which study conclusions or inferences are based (in whole or in part), including null findings and results of secondary or sensitivity analyses. Report results in full in the main text or in supplemental tables or figures as appropriate (see "Supplemental Material" for a list of materials that may be presented in this section). You may organize the "Results" section using subheadings that describe the nature of the results, but do not use declarative statements indicating your conclusions about the findings.

- Provide a clear and concise description of all findings without extrapolating beyond the results being reported.
- Do not describe methods for the first time in the "Results" section.
- Report results of all analyses and experiments that are described in the manuscript, including sensitivity analyses and secondary analyses, in full, either in the main text or in Supplemental Material. Do not limit results to statistically significant results or selected findings that support the study hypothesis.
- If *p*-values are used to interpret findings, report actual *p*-values for all results rather than indicating ranges of *p*-values or statistical significance only.
- Clearly indicate the number of observations for each analysis or experiment, along with information about missing data.
- Include an appropriate measure of precision or variation (e.g., standard errors, 95% confidence intervals) with all summary estimates and estimates of effect.
- Although *EHP* encourages the use of supplemental tables or figures for secondary findings (see "Supplemental Material" for details), present primary results in the main text. This includes results that are mentioned repeatedly, are related to the primary study aims, or are mentioned in the abstract or manuscript conclusions.
- Provide numeric data used to generate figures as supplemental tables whenever possible.

Discussion

Begin with a brief overview of the main study findings.

- Provide a review of the relevant literature and other information needed to put the study findings into context.
- Provide a complete and balanced view of previous research, including findings that are inconsistent with the hypothesis, results, or conclusions of the present study.
- Describe sources in sufficient detail to ensure that readers can assess the quality and extent of the contribution, including:
    - study type or design
    - sample size
    - population or experimental model
    - specific exposures and outcomes
- Provide a frank discussion of study limitations.
- End with a summary of the key findings and their implications for the study question/hypothesis, future research, and policy, as appropriate.
- Do not describe methods or results for the first time in the "Discussion" section.

Acknowledgments

Include sources of funding for the research (if applicable), such as granting agencies, foundations, private support, etc. Authors may also include (as relevant) specific author contributions, acknowledgment of other contributors, information about data sharing, or names of large cohort groups.

Data Sharing

Information about data sharing protocols, options for accessing data, and links to data repositories may be provided in the “Acknowledgments” section, as noted above. Authors may also provide links to data repositories in the “Methods” or “Results” sections of their manuscripts, as appropriate. As is standard practice, genomics data should be deposited into an acceptable repository (e.g., the National Center for Biotechnology Information)

REFERENCES AND CITATIONS

References

Begin the list of references on a new page after the “Discussion” section of the manuscript. Authors are fully responsible for the accuracy and completeness of their references. To avoid extensive queries, please provide complete, accurate information for references, including:

- Author/editor name(s) or authoring agency
- Year of publication
- Full title of article or chapter
- Title of journal or book/proceedings
- For books and meeting reports, city/state/country of publication and name of publisher
- Volume and inclusive page numbers
- PubMed article identifier (PMID) number
- DOI number
- For websites and online documents, the URL and date accessed
- For software, the version number
- For data sets or data files, the electronic location or identifier

If you are uncertain whether to include a piece of information, err on the side of inclusion.

List references alphabetically by the last name of the first author (or subsequent authors if papers have the same first author) followed by the year of publication (earliest to latest). If the first author shares a last name with another first author (Smith JM vs. Smith RB), alphabetize by initials. Distinguish multiple publications in the same year by the same first author using a, b, c, etc. (e.g., Smith JM et al. 2017a, 2017b, 2017c, etc.).

Alphabetize government agencies that are listed as the author by their acronyms followed by the full name of the organization in parentheses, e.g., WHO (World Health Organization). For multiple citations by the same agency, spell out the acronym once at first mention.

In-Text Citations

Place all in-text citations in name/year format immediately after the information cited, with no comma separating the name and the year:

- Single author:
    - The study by Wing (2002)
- A study on this topic (Wing 2002)
- Two authors:
    - The study by Wing and Wolf (2000)
    - A study on this topic (Wing and Wolf 2000)
- Three or more authors:
    - The study by Wing et al. (2008)
    - A study on this topic (Wing et al. 2008)

TABLES

EHP formats tables prior to publication. The editors reserve the right to request that complex tables be simplified to comply with Section 508 requirements.

Direct questions concerning tables to ehp@jjeditorial.com.

Creating Main Text Tables

- Begin each table on a new page after the list of references.
- Create tables using the Table feature in Microsoft Word. Do not submit tables as images.
- Number tables using Arabic numerals (e.g., Table 1, 2, 3, etc.) according to the order in which they are first mentioned in the main text.
    - Do not use the following formats to number tables: Table 1A, 1B, etc.; or Table 1.1, 1.2, etc.
- Ensure that all tables are cited in the main text.
- Give each table a title that describes what is shown but does not summarize results or present conclusions.
- Adhere to the following guidelines to ensure table readability:
    - Do not use more than one layer of row headings.
    - Do not use more than two layers of column headings.
    - Provide a column heading for every column (including the first column), with no additional column heads placed in the body of the table.
    - Do not use shading or colors within the table.
    - Do not merge cells across rows or across columns. All columns within the body of a table must comprise the same number of rows, and all rows must comprise the same number of columns.
    - Do not use italics or boldface for emphasis or formatting within the table.

Table Content

- Use the "±" symbol for arithmetic mean and standard deviation or standard error (e.g., "mean ± SE") and parentheses for the standard error when presented with the geometric mean [e.g., "GM (SE)"].
- Present number and percent as "*n* (%)" in one column.
- Present confidence intervals in parentheses in the same column as the point estimate, with the upper and lower bounds separated by a comma [e.g., (0.1, 2.3)].

Table Notes

- List abbreviations, definitions, and general information about the table in a note immediately under the table (e.g., "Note: All estimates are from logistic regression models adjusted for…"; see table example below).
    - Define relevant populations or samples, models, calculations, and statistical analyses such that the table can be interpreted easily by the reader without having to read the entire manuscript.
    - If *p*-values are reported, clearly indicate the comparison to which the *p*-value applies (e.g., "compared with untreated controls").
- List footnotes after the general note (if one is included) to explain or expand upon specific elements of the table.

- Begin each footnote on a new line.
- Indicate footnotes using lowercase italicized superscript letters, starting over with “a” for each subsequent table. Lettered footnotes within the table should be ordered from top left to top right, next row left to right, and so on.
- Do not use footnotes in the table title.
- Identify footnotes indicating statistical significance in the following order: *, †, ‡, § (asterisk, dagger, double dagger, section). However, *EHP* strongly prefers that authors report numeric *p*-values for all results, regardless of significance, rather than using symbols to indicate categorical *p*-values for selected results only.

Table Example

The table below is for illustrative purposes only; do not submit tables as images. All tables should be created using the Table feature in Microsoft Word.

The table below is reproduced from Casey JA, Morello-Frosch R, Mennitt DJ, Fristrup K, Ogburn EL, James P. 2017. Race/ethnicity, socioeconomic status, residential segregation, and spatial variation in noise exposure in the contiguous United States. Environ Health Perspect 125(7):077017, 10.1289/EHP898.

Table 1. Distribution of anthropogenic L_{50} nighttime, L_{50} daytime, and L_{10} daytime noise among urban residents by race/ethnicity and socioeconomic characteristics at the block group level from the 2006–2010 American Community Survey.

		Median (IQR) anthropogenic noise, dBA[a]		
Characteristic	Total, *n* (%)	L_{50} nighttime	L_{50} daytime	L_{10} daytime
Total population	254,328,850 (100)	44.3 (42.1–46.5)	48.0 (45.1–50.3)	52.9 (50.7–55.0)
Population <5 y	17,112,446 (6.7)	44.5 (42.3–46.7)	48.1 (45.4–50.5)	53.0 (50.9–55.0)
Population ≥5 y	237,216,404 (93.3)	44.3 (42.1–46.5)	48.0 (45.0–50.3)	52.9 (50.7–55.0)
Race/ethnicity[b]				
Hispanic	44,095,827 (17.3)	45.6 (43.3–47.5)	49.5 (47.5–52.3)	54.1 (52.3–56.0)
Non-Hispanic				
American Indian	1,209,132 (0.5)	42.9 (37.9–45.7)	46.1 (37.8–49.7)	51.5 (44.8–54.4)
Asian	13,081,414 (5.1)	45.4 (43.9–47.1)	49.1 (47.4–51.1)	54.0 (52.4–55.7)
Black	32,935,749 (13.0)	45.6 (43.8–47.6)	49.7 (47.6–52.6)	54.2 (52.4–56.3)
White	157,730,767 (62.0)	43.6 (41.3–45.7)	47.1 (43.3–49.2)	52.3 (49.6–54.2)
Income ≤poverty threshold	33,194,588 (13.3)	45.2 (42.8–47.5)	49.2 (46.6–52.2)	54.0 (51.7–56.1)
Income >poverty threshold[c]	216,181,346 (86.7)	44.2 (42.0–46.3)	47.9 (44.9–50.0)	52.8 (50.6–54.8)
CBSA-level segregation				
$0.14 \leq D_m < 0.40$	42,124,233 (16.6)	42.9 (39.2–45.2)	46.7 (41.5–49.4)	51.9 (48.0–54.3)
$0.40 \leq D_m < 0.70$	212,204,617 (83.4)	44.5 (42.5–46.7)	48.2 (45.7–50.5)	53.1 (51.1–55.1)
Total population ≥25 y	35,298,009 (100)	44.6 (42.4–46.8)	48.5 (45.7–50.9)	53.3 (51.2–55.4)
<High school education	5,837,943 (16.5)	45.4 (43.0–47.6)	49.4 (46.7–52.3)	54.1 (51.8–56.1)
≥High school education	29,460,066 (83.5)	44.4 (42.3–46.6)	48.3 (45.6–50.7)	53.2 (51.1–55.3)
Total households	95,455,047 (100)	44.3 (42.2–46.5)	48.1 (45.2–50.4)	52.0 (50.9–55.1)
Median household income (USD)				
Quartile 1 ($2,868–$39,229)	23,863,693 (25.0)	45.6 (43.2–47.7)	49.8 (47.3–52.8)	54.5 (52.4–56.5)
Quartiles 2–4 ($39,230–$249,896)	71,591,354 (75.0)	44.0 (41.8–46.0)	47.6 (44.5–49.6)	52.6 (50.4–54.5)
Linguistically isolated households	5,140,332 (5.4)	45.9 (43.9–47.9)	50.4 (48.2–53.3)	54.8 (53.0–56.8)
Nonlinguistically isolated households	90,314,715 (94.6)	44.2 (42.1–46.4)	48.0 (45.0–50.2)	52.9 (50.7–54.9)
Housing tenure				
Renter-occupied homes	32,996,266 (34.6)	45.3 (43.3–47.4)	49.5 (47.2–52.3)	54.2 (52.3–56.3)
Owner-occupied homes	62,458,781 (65.4)	43.8 (41.6–45.9)	47.4 (43.9–49.4)	52.5 (50.0–54.3)
Total families	63,521,803	44.1 (41.9–46.3)	47.7 (44.6–49.9)	52.7 (50.4–54.7)
Unemployed families	3,343,134 (5.3)	44.5 (42.3–46.8)	48.2 (45.4–50.6)	53.1 (51.0–55.2)
Employed families	60,180,669 (94.7)	44.1 (41.9–46.2)	47.7 (44.5–49.9)	52.7 (50.4–54.7)

Note: CBSA, Core Based Statistical Area; dBA, A-weighted decibels; IQR, interquartile range.
[a]Population-weighted by block group population (population <5 y, and race/ethnicity), by number of families (unemployment), by households (household income and linguistic isolation, and renters/owners), by population for whom poverty status was determined (poverty), and by population ≥25 y (<high school education).
[b]Race/ethnicity does not sum to total; 5,275,961 individuals were of mixed or other race/ethnicity.
[c]4,952,916 people did not have poverty status determined and thus are not included in the poverty summary.

FIGURES

EHP does not redraw or format author images prior to publication. It is the authors' responsibility to ensure appropriate figure numbering, quality, and sizing to avoid publication delays.

EHP editors reserve the right to request that complex figures (e.g., figures with multiple panels showing information in a variety of formats, or that include panels related to different experiments) be divided into separate figures for publication. Authors also may be asked to edit figures to comply with Section 508 requirements.

Direct questions concerning figures to ehp@jjeditorial.com.

Creating Main Text Figures

- Number figures according to the order in which they are first mentioned in the main text.
- Ensure that all figures are cited in the main text.
- Adhere to the following guidelines to ensure figure readability:
    - Do not use color as the only means of conveying information; use contrast, patterns, or symbols instead of color (or in addition to color) whenever possible.
    - Whenever possible, ensure that all images can still be interpreted when printed in black and white.
    - Ensure correct spelling for all figure text.
- Clearly label all axes, giving both the measure and the unit of measurement where applicable.
- Ensure that all letters, numbers, and lines are clearly legible and easy to differentiate.
- When possible, ensure that terms are styled the same in figures as they are in the main text (e.g., subscript the "10" in "PM_{10}" in both the text and the figure labels/legends).
- Ensure that terms and styles (including symbols and colors) are consistent across figures. For example, if Figure 1 is a scatterplot and Figure 2 is a bar graph, you might use a black circle to represent the control in the scatterplot and a black bar to represent controls in the bar graph.
- For photomicrographs, include a scale bar in each image, and specify the length in the typed figure caption (e.g., "bar = 10 μm").
- You may adjust an image for brightness and contrast if you apply the change to the entire image. Do not remove background data of gels and blots. The final image must accurately represent the original data.

Figure Size

- Figures may be no larger than 7.0 inches in width. Ensure that reducing a figure to this size does not compromise readability, quality, or interpretability.
- Ensure that text within each image is of similar size, with point sizes between 6 and 8 points when reduced to final publication size.
- These guidelines also apply to figures with multiple panels. *EHP* does not have the ability to rearrange panels within a figure to meet the size requirement.

Saving and Submitting Figures

- Save and submit each figure in one of the following formats:
    - PDF (fonts must be embedded)

    - PS/EPS (embed fonts, or use system fonts only: Helvetica, Courier, Arial, Times)
    - TIFF (no layers, LZW compression, Interleaved Pixel Order, IBM Byte Order, minimum 300 dpi, 600 dpi preferred, minimum 8-bit color depth)
    - JPG (may be submitted if higher-quality image formats are not available; minimum 300 dpi, 600 dpi preferred, minimum 8-bit color depth)
- Submit only one version of each figure, but format can vary by figure.
- Submit figures with multiple panels as a single file.
- Include the figure number in the filename of each figure (e.g., “Figure 1.pdf”).
- Do not embed figures in the main text file, and do not duplicate the image caption in the figure image.

Figure Captions

- Provide figure captions on a new page of the main text after tables.
- Include a title for the entire figure and descriptors for each panel [e.g., “Figure 1. Incidence of hepatocellular adenomas (*A*) and carcinomas (*B*) in mice exposed to DEHP”].
- Figure titles should describe the figure and not interpret its meaning or present conclusions.
- Define error bars and any abbreviations not defined in the figure itself.
- Define relevant populations or samples, models, calculations, observations per data point, and statistical analyses such that the table can be interpreted easily by the reader without having to read the entire manuscript.
- Define all elements of the figure, including symbols, whiskers, and lines or bars that are not already defined within the image itself.
- If statistical significance or *p*-values are reported, clearly indicate the comparison(s) to which they apply (e.g., “compared with controls from the corresponding age group”).
- Provide a credit line for any images reused with permission from the copyright holder. Present credit lines as the copyright holder requires; do not reword.
- Provide footnotes directly after the abbreviations beginning on the next line. Identify footnotes indicating statistical significance in the following order: *, †, ‡, § (asterisk, dagger, double dagger, section). However, *EHP* strongly prefers that authors report numeric *p*-values for all results, regardless of significance, rather than using symbols to indicate categorical *p*-values for selected results only.