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Assessing the Effect of Air Pollution and Heat Stress on Health in Nairobi City: A Geohealth Project (Kenya)

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Abstract

The environmental and occupational burden of disease is ravaging the global economies, with the combined burden of disease and DALYs constituting at least 25%. This has reached alarming levels in developing countries, with over 60% of this burden borne by the Sub-Saharan Africa. To partly address these concerns, the Global Environmental and occupational health (GEOHealth) Eastern African Hub has been established. The five-year research, training and capacity building Hub runs from Sept 2015 till August 2020, with an aim of building capacity, training and conducting research to generate evidence for policy in air pollution, climate change and occupational health. The specific objectives are to: (i) assess the effect of ambient air pollution on cause-specific hospitalization and mortality; (ii) assess the effect of ambient and indoor air quality on child pulmonary function in Nairobi; and (iii) to assess the effect of heat stress on workers engaged in flower green houses in the neighbourhoods of Nairobi city. Multiple study designs will be used to meet the above objectives of the Nairobi based research as follows: (i) continuous measurement of the level of ambient air pollution ($PM_{2.5}$) prospectively in a central site in the city in parallel with collecting secondary data on hospital admission and discharge in 6 hospitals; (ii) nephelometric measurement of micro-catchment air pollution around 10 schools, to be related to the spirometry tests of one thousand 10 year old pupils; and temperature and Relative humidity measurements to determine heat stress in occupational settings. Data will be collected using different equipment such as: air quality measuring instruments (Beta Attenuation Monitor and Nephelometer); Spirometer for pulmonary function test (PFT); and Easy Log RH / Temp Data loggers for Occupational Health stress. In addition, questionnaires will be used for background data, and data acquisition checklist for secondary data. Data will be entered and cleaned using Epi Info Ver 3.5.1, and the analysis done using SPSS V 20.0. Summary statistics, multivariate regression using Ors with 95% CI, exposure modelling will be utilized to describe the study subjects and exposure levels to air pollution. The Hub activities in Kenya are already ongoing, with progress made in many fronts. Ethical clearance and permission for data collection will be

Keywords: *Air Pollution Exposure, Air Quality, Cause of Mortality, Heat Stress, Morbidity, Nairobi, Respiratory Epidemiology, Spirometry.*

1. Introduction: About GEOHealth

The Global Environmental and Occupational Health (GEOHealth) project is global network, with a local East Africa HUB (chapter), and is expected to be operational for 5 years, effective October 2015. The focus of the network is collaborative regional capacity building / training, research, and policy and institutional development in climate change for health, air pollution (indoor and outdoor), and occupational health. It's led by the universities, but draw a wide range of stakeholders from government, NGOs, CBOs, multi-lateral agencies, research bodies and policy institutions so that there is relevant research and appropriate training whose products are directly consumable by the participating organizations. So far twelve universities (two from Kenya, one from Uganda, 4 from USA and 5 from Ethiopia) are involved, with 2 primary institutions being University of Southern California (USC) and Addis Ababa University (AAU). Kenya is represented by University of Kabianga (UoK) and Great Lakes University of Kisumu (GLUK).

The GEOHealth program supports paired consortium led by a Low middle-income country institution (LMIC) and a U.S. institution to plan research, research training and curriculum development activities that address and inform priority national and regional environmental and occupational health policy issues. A GEOHealth hub for Eastern Africa was proposed since 2012 when it competed and won a planning grant for its established. This was under the auspices of the AAU and USC in 2012. Since 2013, the effort was made to initially spread the network to other Eastern African countries such as Kenya, Rwanda, and Uganda. It was expected that in the future, more countries will be included to cover the entire eastern Africa region, including Burundi, Somali and Tanzania. The choice of East African Region was because it was facing multiple challenges, including: Malnutrition, Poverty, Infectious, diseases and threat of non-communicable diseases (NCDs) emerging. The Burden of disease from environmental and occupational hazards is a growing concern. In addition,

there is lack of data and limited human capacity in key areas, justifying a need for a comprehensive systematic review and strategic action. The GOEHealth Eastern Africa Hub thematic areas for the Hub are: (i) Occupational Safety and Health; (ii) Climate Change for health; and (iii) Air Pollution (indoor and outdoor). These are to be assessed and strengthened in terms of collaborating training, research, policy advocacy and institutional development through a full HUB expected to run for 5 years. Collaborating research is expected to generate actionable policy from the empirical research evidence. However, before the Full hub establishment in 2015, there were planning activities in the region between 2012 and 2015, which culminated in the publishing of situational analysis and needs assessment (SANA) report from each of the four countries. Kenya published its SANA report, with key findings highlighted below.

2. The Kenya SANA (2012-2015)

The country specific situation analysis and needs assessments were done in all four countries between 2-12 and 2014, with the results shared in a workshop in Addis Ababa, Ethiopia. The SANA Kenya found serious training, institutional, research and policy gaps in universities, research, policy institutions especially in their dealings with occupational health, indoor air pollution, outdoor air pollution and climate change for health. After signing the MOU, letter of commitment and willingness to support the HUB activities were written by the agencies, after which the team expanded to cover the themes, and plan of action developed. The SANA report was finalized and submitted in August 2014 and published in 2015.

2.1. Key Highlights of the Results of the Kenya SANA

I. Courses and research in all the four themes are conducted by Universities, private and public institutions of higher learning;

II. Most courses are repeated with none standing out to deliberately help break from the past; most are generic, with newly established universities literally carrying some of the curricular of their mother / mentoring institutions to start them off; they wake up a few years later to start their own.

III. It takes new universities up to 2-4 years before they fully embark on establishing their own new independent programs aiming at creating a niche.

This includes the period they are university colleges, to post charter issue.

IV. Courses are chosen and done for prestige, employment and peer / societal pressure, and not necessarily to make a change or out of passion. As a result, only very few progress in work and research in their line of training. Due to availability of bank clerical jobs, it has become one major outlet for fresh environmental graduates. This leaves the areas with limited number of capable professionals to push the agenda forward.

V. Researchers are done in a wide range of thematic areas, but are, like the training/ education, rather generic. There are repeats and inconsistencies, resulting largely from lack of reliable database to guide any new upcoming researchers to avoid repeats, and acknowledge past relevant researches.

VI. For the climate change, indoor and outdoor air pollution, occupational health, there is hardly any data to rely on. There is a conspicuous lack of capacity in terms of human and physical (infrastructural and equipment); It's even worse when the dimension of establishing a link with health is concerned, because of lack of basic technical data. Most researches have gone for the KAP about climate change, which are largely subjective and based on own feeling of comfort or otherwise at the time.

VII. Most local researches never have a use / life beyond the thesis defence stage and graduation of the researcher with a MSc or PhD degree. A small percentage of the research theses are only available in the parent universities and research institutions and only a few universities avail a limited amount of the content (abstract) online. The body largely remains available to only those who can get physical access. Because of local long protocol to access the documents in the reserved section of the libraries, they largely remain unused and un-cited in published literature. As such they literally rot and collect dust. For the less than 1% published, its done on the average 5-15 years after the graduation, rendering the age of the key references to be at least 10 years at the time of publication. This makes the publication data near stale, and not useful in policy.

VIII. Due to both the weaknesses of the research and data thereof, it has been difficult to generate policy from independent local research. Most policies are generated from international research, or those funded by international and foreign bodies. At least 90% of the policies are not home-grown. This renders one-off researches rather tricky, because they hardly leave any data

behind for local use. As such, there are serious 'research study gaps' on the thematic areas.

IX. Because most policies originate from outside the region, their local implementation is not easy, resulting in much policy implementation gaps.

X. It's rather difficult to both write a new curriculum and change the structure of an existing university curriculum in large, established public universities; it's much easier in smaller universities. However, even in the latter, there are key capacity gaps in specialised areas.

XI. Due to this advantage, the small institutions are taking lead in diversifying their programs by creating new ones and / or reviewing the existing ones for the current and proposed programs;

XII. There are many policies on the four thematic areas already developed by the government of Kenya in collaboration with line ministries.

XIII. In the Kenyan cities, both indoor and outdoor air pollution are beyond the threshold, rendering them key sources of exposure to city dwellers and the household members.

XIV. The outdoor exposure is closely associated with occupation (e.g. traffic police, outdoor service providers such as hawkers and small traders, etc) while the indoor exposure is faced more by smaller children, women etc in rural households in hot seasons, while both rural and urban residents in informal settlements face the wrath of indoor air pollution especially in June-August when they use a wood fuel means to warm the houses.

XV. Whereas studies have been done in all the thematic areas, very few scientifically consistently link them to health, unless they are social (KAP) studies which largely assess perceptions, rendering them rather subjective.

The Eastern African GEOHealth Hub submitted its grant application in late 2014 and won in Sept 2015. This SANA gave rise to the current study in the Hub. Since Oct 2015, a series of administrative and capacity building activities have taken place to actualize the hub. The offices have been established in all the four countries.

3. The current Geohealth hub studies 2016-2020

3.1. Introduction

Many African economies have been traditionally heavily dependent on Agriculture. However, in the last two decades, the African countries significantly shifted to industrialization and urbanization. In Kenya, this is enshrined in the constitution 2010 and Vision 2030. As such, with flagship projects to help it achieve the targets, Kenya, has made great effort to overcome the low economic growth experienced after the post-election violence in 2007/8 period. Believing that the economy growth is sustainable if it maintains our environment clean and safe, the various policy documents have mainstreamed environmental quality as a right. However, development and improved living conditions are expected to produce pollutants which are hazardous to human health and the environment. The greatest burden of diseases in Kenya are already attributed to environmental and occupational burdens associated with air and water pollution, occupational hazards, pesticides, and attributes of climate changes. However, there is insufficient reliable data to help plan the future, rendering environmental and occupational hazards the greatest possible danger to human health in the country as urbanization and industrialization continue. It's evident a paradigm shift is inevitable, as Kenya grapples with the increasing burden associated with non-communicable conditions. Given this growing concern, there is a need to generate scientific evidence that relates environmental issues with health outcome. This is the essence of the GEOHealth Kenya research.

Purpose of the project is to assess the effect of exposure to air pollution on children's health and daily mortality/morbidity; and effect of heat stress on worker's health. The GEOHealth Research Project involves three main themes.

Theme 1: Children's' health study (CHS) related to exposure to ambient air pollution

Theme 2: Daily Hospital based Morbidity and Mortality related to exposure to ambient air pollution

Theme 3: Heat stress among green house workers

3.2. The specific objectives under each theme are indicated as follows.

1. Children's health study**:** to determine the chronic effects of ambient $PM_{2.5}$ and black carbon on childhood lung function and respiratory symptoms in Nairobi

1.1 To measure and define temporal and spatial variation in outdoor and indoor levels of $PM_{2.5}$ and black carbon in Nairobi

1.2 To characterize household level exposure $PM_{2.5}$ and black carbon

1.3 To determine the chronic effects of ambient $PM_{2.5}$ and black carbon on childhood lung function and respiratory symptoms in Nairobi

2. Study on daily morbidity and mortality: To assess and compare the short-term effects of temporal fluctuations in ambient PM2.5 on overall and cause-specific hospitalization and mortality in Nairobi

2.1 To measure daily levels of ambient PM2.5

2.2 To ascertain overall and cause-specific hospitalization and mortality

3 Heat stress among workers: to determine the levels of current occupational heat stress among workers in key industries (e.g., flower greenhouses) and to examine the validity of models to predict future heat stress among workers.

4. Methods

Multiple types of study designs will be used to meet the above purpose. The measurement of air pollution around 10 schools will be related to the lung function tests and respiratory health of 10 years aged school children. The sample size for children's respiratory health study is 1000, with 100 sampled from each sub-county / school. Data will be collected using different tools and instruments: air quality measuring instruments (the nephelometer), questionnaire for background data, spirometer, and data acquisition checklist for secondary data. Data will be entered and cleaned using Epi Info Ver 3.5.1, and the analysis in SPSS V 20.0. Summary statistics, multivariate regression using Ors with 95% CI, exposure modeling will be utilized to describe the study subjects and exposure levels to air pollution. Ethical clearance and permission for data collection will be sought from appropriate institutions. Consent and assent will be obtained from guardians and study subjects.

5. Study design by respective objectives

SN	Objective	Study design/ methods
1	To measure and define temporal and spatial variation in outdoor levels of $PM_{2.5}$ and black carbon in Nairobi, Kenya	Continuous central site monitoring for $PM_{2.5}$ both at city and sub city levels
2	To assess and compare the short-term effects of temporal fluctuations in ambient $PM_{2.5}$ on overall and cause-specific hospitalization and mortality in Nairobi	Time series study of counts of patients of morbidity and mortality
3	To measure daily levels of ambient $PM_{2.5}$	Central site monitor using real time BAM 1022 equipment
4	To ascertain overall and cause-specific hospitalization and mortality	Hospital based electronic medical records
5	To characterize household level exposure $PM_{2.5}$ and black carbon	Household air pollution assessment using nephelometers
6	To determine the chronic effects of ambient $PM_{2.5}$ and black carbon on childhood lung function and respiratory symptoms in Nairobi	Spirometry test on 1000 ten-year-old children in Nairobi's 9 sub-counties

6. Key milestones and achievements since 2015: winning the grant to date

Nov 2015	Print out Kenya SANA report, GEOHealth	Distributed to various stakeholders
Jan 2016	Regional workshop in Addis Ababa	Attended by 2 representatives from Kenya; A Afullo and Kevin Achola
	Seek guidance on research clearance by GoK (NACOSTI);	
14th March	Receive NACOSTI research authorization for GEOHealth	
March 2016	Seeking list of hospitals for GEOHealth research;	
	Signing of the AAU-UoK MOU	
11th April 2016	County commissioner approves the research	
12th April 2016	County director of education, NBI Approves the research	
14th April 2016	Visit Nyayo House, county education director's office for updated school list with enrolment. Apply to TSC research, planning and policy directorate, Upper hill,	Official updated list of schools available; Approval granted 18.4.16 by TSC,
18th April 2016	Access the updated list of primary schools in NBI county	
19th April 2016	Travel to USC for a 3-week PI training workshop	
June 2016	UoK receives the first batch of funds (21,000 USD)	
July 2016	Local 4-day HAP training workshop at HOAREC, ADDIS	PI travels with Yegon chepkutto
August 2016	Purchases for office establishment; (university approval of 8% admin fee; GoK tax exemption on BAM)	
	Following up approval of UoK researchers as Co-Is by NIH.	W Yegon Chepkutto and Alfred Koskei
August/ Sept	Following up IRB issue, IREC establishment and NACOSTI approval of the IRB	
Oct 2016	Procurement of BAM from MET-ONE	

7. Research timeline and work plan for Kenya

The project life is 5 years: Oct 2015-Sept 2020. The study organization is being established in Year 1. The indoor air pollution assessment with children's health, exposure to $PM_{2.5}$ and school children's health, and occupational exposure assessment will be done cross-sectionally in Year 4.

Studies/ Objectives	Year 1	Year 2	Year 3	Year 4	Year 5
Research Office Organization	XXX				
Outdoor air pollution		XXX	XXX	XXX	XXX
Hospital based morbidity and mortality		XXX	XXX	XXX	XXX
Indoor air pollution and Personal Exposure Assessment				XXX	
Children's health Study (KECHS/ EACHS)				XXX	
Occupational exposure/ heat stress					XXX

7.1. Budget and its source

The total budget is USD $293,846.40 (29.4 mill Kshs). The fund sources are from National Institutes of Health (NIH) of USA and its partner International Development Research Centre (IDRC) of Canada.

7.2. Expected outcome

At least 5 scientific papers will be generated and published in reputable journals. Policy briefs will be prepared and disseminated to relevant stakeholders, some of whom are already part of the project.

8. Progress since 2012

8.1. The following has been the progress made since 2012

1. Primary partners, USC and AAU team up and apply for the planning grant on offer by the NIH, USA;

2. The primary partners conduct the situation and analysis and needs assessment (SANA) for Ethiopia and share the results with universities and stakeholders in ADDIS;

3. The network expands its wings to cover more countries such as Kenya and

Uganda; MOUs are signed.

4. Situational analysis and needs assessment done by the partner institutions in Kenya and Uganda;

5. Visits to partner universities and stakeholders made by USC and AAU in Kenya and Uganda

6. Regional workshop conducted in ADDIS, in which jelling of the team, as well as sharing of the results of the MINI-SANA for Kenya and Uganda formed the core theme; stakeholders give their take on these presentations.

7. Regional workshop done in Kampala in 2015; attended by 4 participants from each country (2 University and 2 agency representatives);

8. Conduct another planning workshop in Addis in January 2016 to plan for the grant after awards confirmation;

9. PIs attend a 3-week training workshop in USC, USA from April 2016-May 2016; also attend a NIH workshop in Maryland.

10. June 2016: Funds are disbursed to the Universities to initiate the activities.

11. 2 university representatives per country participate in a household air pollution (HAP) workshop in Addis in July 2016;

12. Aug-Sept: administrative aspects of GEOHealth ongoing in the various universities, including establishing the GEOHealth offices.

8.2. Personnel plans

	#	1	2	3	4	5
Research Director / PI		X	X	XX	XX	X
Co-Investigators	3	X	X	XX	XX	X
Research administrator	1	X	X	X	X	X
Field researcher 1			X	X	X	
Field researcher 2				X	X	
Field Researcher 3					X	
Data manager			X	X	X	X
Data clerk			X	X	X	
Program analyst			X	X	X	X

Acknowledgement

We wish to acknowledge the National Institutes of Health (NIH), USA and the International Development Research Centre (IDRC), Canada for funding the GEOHealth Eastern African Hub.

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