Developing a Clinical Assessment Tool for Screening Lead Exposure Levels During Pregnancy and After Delivery

Bontle Mbongwe

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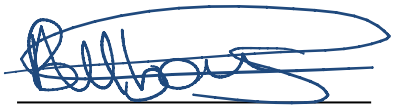
DEDICATION

In loving memory of my father, Ernest Ishmael Raowesi Motladiile (“Mdakes”), and my mother Onkabetse Mmasetshwanaka Motladiile (“Mma Mdakes”)

DECLARATION

I, Bontle Mbongwe, declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy in the University of Pretoria. It has not been submitted before for any degree or examination at this or any other tertiary institution.



Bontle Mbongwe — January 30, 2013

Date

Commissioner of Oaths — Date

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By

Bontle Mbongwe

Submitted in fulfillment of the requirements for the degree

Doctor of Philosophy

Supervisor: Prof. Kuku Voyi
School of Health Systems and Public Health
Faculty of Health Sciences
University of Pretoria

Co-Supervisor: Prof. Halina Röllin

Environment and Health Research Unit, Medical Research Council of South Africa
Johannesburg, South Africa

School of Health Systems and Public Health
Faculty of Health Sciences
University of Pretoria

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SUMMARY

Lead is a toxic heavy metal associated with adverse health effects ranging from developmental neurotoxicity to reproductive effects. While lead affects people of all ages, infants and children are the most vulnerable and susceptible to the neuro-developmental effects of lead exposure. Maternal blood lead concentrations that do not produce clinical toxicity on pregnant women have been linked to adverse offspring development. Observed reproductive effects to low lead levels during pregnancy include the risk of spontaneous abortions, effects on birth weight and preterm birth. There are particular concerns with regard to reductions in IQ scores. Research evidence suggests that an incremental increase in blood lead levels of 1 µg/dL is associated with approximately 1 IQ point deficit. Of particular concern is that currently no threshold has been observed or exists for developmental neurotoxicity to the chronic low lead exposures levels. While the developed countries have built evidence for lead exposure sources, have identified the most vulnerable groups to lead exposure, and have instituted control actions for lead exposure, it is not the case in developing countries such as Botswana. Currently, there is very little knowledge about the potential sources of lead exposure among different population groups not only in Botswana but also in most developing nations. There is also an evident limited knowledge on the behaviours and practices of different population groups that could potentially expose them to lead in developing countries.

This thesis explores the following questions: i) Are there specific risk behaviours and practices peculiar to pregnant women in Botswana that could potentially expose them to lead? ii) What are the environmental lead concentration levels and their potential to expose pregnant women? iii)What are the blood lead concentrations at each stage of pregnancy and after delivery in Botswana and, iv) Can we use the information from these three questions to predict lead exposure levels during pregnancy and after delivery? v) Can we use the new information to a develop a policy dissemination brief to inform policy on lead exposure sources in Botswana, develop guidelines for health professionals for assessing and screening lead exposure levels during pregnancy and after delivery, develop an awareness leaflet for lead education?

To address the specific risk behaviour and practices of pregnant women, a comprehensive validated risk assessment questionnaire was administered among 142 pregnant women during the first trimester of pregnancy (defined as 8-12 weeks) in four villages of different geographical settings and nomenclature (small/rural, major and semi urban). For purposes of this work the validation process involved obtaining information (from experts in the field and communities)

relevant to the purposes of the study and to confirm that the tools employed for collection of data in all trimesters were suitable in terms of both construct and content. Data was collected between September 2009 and February 2010.

To address potential environmental sources of lead exposure during pregnancy soil (n=28), water (n=28) and traditional cosmetic clay - *letsoku* (n=3) samples were collected in November 2010, February 2011 and May 2011 from the homes and in the vicinity of the study population to determine lead concentrations.

To know baseline blood lead levels at each stage of pregnancy, blood samples were collected from September 2009 to February 2011 from pregnant women between weeks 8-12 (first trimester, n=137), 20-24 (second trimester n=126) and weeks 34-36 (third trimester n=106). Blood lead levels of women who completed the entire study from trimester on until after delivery (n=63) were then used to construct blood lead prediction models using statistical models.

Pregnant women in the study area ingested non-food items such as soil, match sticks, pencil, chalk and animal feed such as bone meal (86%). Women applied used and unused car oils (in particular brake fluid) and other harmful substances for "treatment of skin conditions and for beautification purposes (74%). Older women (defined as >35 years in this study) were at a significantly higher risk to ingest soils ($p<0.01$). Mean (±SEM) lead concentrations in water exceeded the WHO drinking water quality standards nineteen fold (0.19±0.019 ppm (n=28) Major villages, had significantly higher Pb concentrations ($p<0.05$) in soils and water compared to small villages. Mean blood lead levels (±SEM) for the first, second and third trimesters were 1.96(±0.14)µg/dL, 2.49(±0.17) µg/dL, 2.66(±0.19) µg/dL respectively. Blood lead levels increases from the first to third trimester ranged from 1.6-5%. Blood lead concentrations significantly differed among locations ($p<0.01$). The highest concentrations were observed in women from smaller villages that were poorer ($p<0.02$).

Pica, multiple risk behaviours/practices (engaging in two or more risk behaviours/practices), trimester of pregnancy, poor food supplementation and diet were predictors of blood lead levels ≥ 2µg/dL. There was a dose response relationship between supplement intake and an increase in blood lead levels.

These findings suggest that pregnant women and their unborn babies could potentially be exposed to lead because of the environment in which they live, their economic status, lifestyle, behaviors and practices. Drinking water is a potential threat for lead exposure, not only among pregnant women, but other vulnerable groups such as infants and children. This study is the first in Botswana and one of the few in Africa to investigate lead exposure sources at each stage of pregnancy and after delivery. It is also the first to identify new potential lead exposure behaviors and practices such as the application of auto oils by pregnant women for treatment of skin diseases. The findings suggest the need to train health workers and equip them with the skills and knowledge to assess and screen women who could potentially be exposed to lead. Further, pregnant women need to be sensitized on potential lead exposure sources, to prevent lead poisoning. This study has been able to use the results to develop a policy brief for disseminating the results to decision makers, guidelines for utilization by health workers to screen lead exposure levels and an awareness leaflet for pregnant women. These have been validated and pretested at community and Government levels.

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