



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

Bontle Mbongwe

The financial assistance from the Universities of Botswana (UB) and Pretoria (UP) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to UB and UP

ACKNOWLEDGEMENTS

I am aware and acknowledge fully and completely the fact that had the Almighty, God, not given me life when I started this project and at this moment as I write this thesis, there will be no thesis. I thank God.

I am grateful to have met and worked with two great supervisors Professors Kuku Voyi and Halina Röllin who provided guidance and support throughout this work. It was a long journey with too many hurdles ranging from conceptualising this project to funding limitations and yet “Kuku” and “Halina” (as I have comfortably drifted from addressing them as Profs!), were there to keep me going. No words can ever describe adequately how grateful and honoured I am to have met these two great ladies. Thank you, *ke a leboga*.

I thank the Universities of Botswana (UB) Pretoria (UP) for financially supporting this work. I particularly acknowledge the School of Health Systems and Public Health for providing me with a grant that enabled me to stay enrolled at UP, when funds diminished from my main sponsor UB. Professor Mazonde and Clement Matasane of the Office and Research & Development (ORD) of UB for facilitating the matching funds to keep me going at a time of dire need. Mme Mma Mokane from UB Training Department, your constant support and interest in my success will never be forgotten.

Thank you to the Ministries of Health, Local Government and Diagnostifirm Laboratories, for availing your laboratory facilities, equipment and staff for this work. I am grateful to the staff of Sekgoma Memorial and Palapye Primary Hospitals for being loyal to this project and treating it as their own as well as the cordial relationship they developed with me and my research assistants. Professor Kiran Baghat, my friend, my colleague, my doctor, thank you for all the support, and most importantly for connecting me to Diagnostifirm Laboratories who sponsored the collection, shipment and analysis of my samples.

I am grateful to the Ministry of Health, Research and Ethics Committee for first granting me the permission to do the study and secondly for providing timely annual reviews for project modifications due to constraints on the ground. Most importantly, I thank the research participants and their families for creating this wonderful opportunity to understand lead exposure issues in Botswana. Without you, there will be no knowledge. I am grateful to all my research assistants who not only worked tirelessly to collect data, but also motivated the women

to stay in the study. A very special thank you to Ms Gakebitse Ntau (“Mma Msadi”) my midwife research assistant who taught me a lot about pregnancy and all the terminology involved. Thank you Khumalo Tshambani and Neo Mbongwe for spending endless hours in the lab preparing the samples for shipment! Thank you Royal Chalashika of the Cartography section of Statistics Botswana in the Ministry of Health and Thank you Rre Motsumi and Gift Mbuya of the Cartography section of the Ministry of Agriculture for developing maps for this project.

The validation of the lead screening tool, the policy brief and the awareness booklet were three very crucial deliverables of this work. I am grateful to the following divisions of Ministry of Health; Disease Control, Health Education and Promotion, Maternal and Child Health, Sexual & Reproductive Health, and the Food and Nutrition for reviewing and validating these documents. Most importantly, the health professionals in the study area and the study women have added an invaluable input into these documents from the project inception. Thank you to Dr. Reginald Machaba-Hove and staff of the UB Department of Environmental Health for having the final review on the intervention tools and giving them thumbs up. I am also grateful to Dr Piet Becker (MRC bio statistical unit) for his invaluable statistical advice.

Beza Belayneh, Braimoh Bello, Pamela Gwanzura, thank you for rescuing me just at that moment when I was about to lose hope. Thank you to my friends, relatives and all those I may have not singled out.

Finally, in a very special way, from the very bottom of my heart, I am ever so grateful to my loving husband, Jowitt Mbongwe (“Jowi”), my two daughters Neo (“Mma Mneux”) and Wedu (“Miss Wedu”) and my son Tashata (“Tish”) whose love, motivation and support I will forever cherish.



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.

A handwritten signature in blue ink, appearing to read 'Bontle Mbongwe', written over a horizontal line.

Bontle Mbongwe

January 30, 2013

Date

Commissioner of Oaths

Date

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

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

January 2013

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 (\pm 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 (\pm SEM) for the first, second and third trimesters were $1.96(\pm 0.14)\mu\text{g/dL}$, $2.49(\pm 0.17)\mu\text{g/dL}$, $2.66(\pm 0.19)\mu\text{g/dL}$ 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 $\geq 2\mu\text{g/dL}$. 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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