

## Chapter 7

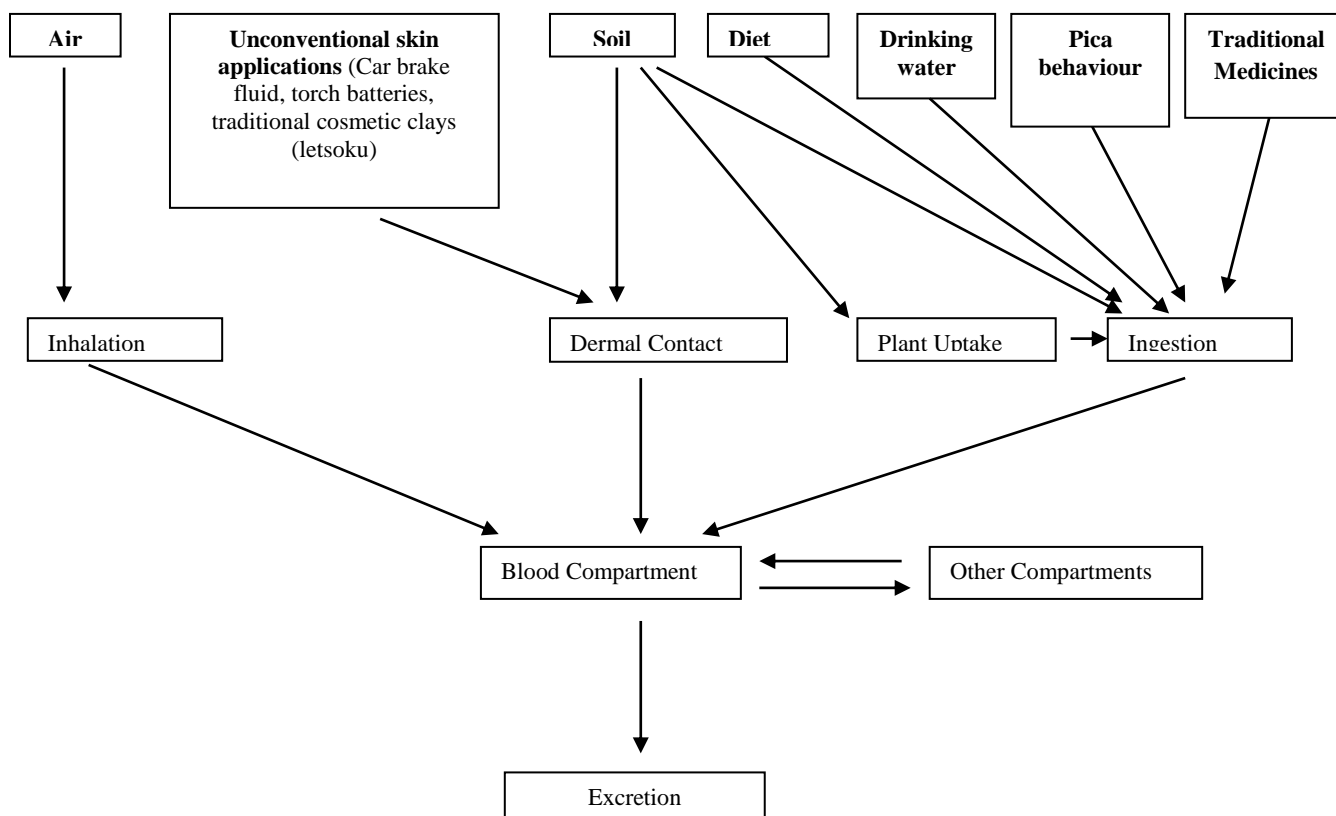
### Developing a Screening Tool For Assessing Lead Exposure Levels during pregnancy and after Delivery

#### 7.1 INTRODUCTION

##### *7.1.1 Building a case for lead exposure prevention programs during pregnancy and after delivery*

A review of literature in chapters 1 and 2 of this thesis highlighted the true extent of the difficulty to measure lead poisoning, particularly in developing countries due to limited data. The problem of limited data on lead poisoning, particularly in the adult population is recognised in the developed world as well despite such countries having blood lead epidemiology and surveillance programs in place to monitor reported elevated blood lead levels.<sup>1</sup> Lead poisoning can present with nonspecific signs and symptoms such as abdominal pain, constipation, irritability, difficulty concentrating and anaemia. It is crucial that health professionals are aware of these symptoms and diagnosis in order to assess and document early health effects. Research has evidently established that chronic exposure to levels of lead too low to trigger symptoms, can increase the risk for hypertension<sup>2</sup> and accelerated future cognitive decline in adults.<sup>3</sup> Chapter 2 also highlighted potential challenges for clinicians to misdiagnose lead toxicity in their patients due to its vague symptoms particularly in developing countries where clinicians may have never attended to a lead poisoning individual because lead screening may have never been done.<sup>4</sup> Chronic low dose exposure may manifest with non-specific gastrointestinal disturbances, subtle neurologic and subclinical cognitive deficits.<sup>5, 6</sup> Delays in the diagnosis of lead poisoning as a result of the lack of awareness of the symptoms of lead poisoning and subsequent misdiagnosis has resulted with adverse consequences.<sup>7</sup> The greatest hope in lead poisoning incidents is that the removal of the lead source has proved to be sufficient to relieve the symptoms and reduce the lead load, particularly in low lead cases.<sup>8-11</sup> The results of this work have shown a dose response relationship in terms of diet and lead exposure. Women who consumed more iron and

calcium supplements had lower blood lead levels compared to women who consumed none. A key recommendation that consistently emerged from all the chapters of this thesis emphasized the need for health professionals to be aware of lead and its detrimental effects on maternal and child health in order for them to be proactive in early detection and prevention of lead exposure and subsequent lead poisoning.



**Figure 7.1 Conceptual model of lead exposure during pregnancy and after delivery**

The overall aim of this thesis was therefore to develop a cost effective clinical assessment-screening tool for lead exposure levels during pregnancy and after delivery. The previous chapter (Chapter 6) has identified the best fit model for lead exposure in pregnant women aged 18 to 42 in the Central District of Botswana. The model identified multiple risk factors, trimester of pregnancy, consumption of calcium and iron supplements and citrus fruits, pica behaviour and source of water supply as independent.

risk factors for lead exposure during pregnancy and after delivery. The multiple risk behaviours included pica behaviour, the uses of unconventional skin treatment solutions, the alcohol consumption, tobacco use and traditional medication use.

The objective of this chapter is therefore to present a conceptual model (figure 7.1) of lead exposure during pregnancy in Botswana and key interventions developed as a result of the model.

Previous models have focused on predicting child blood lead levels for residential exposure scenario and for adult blood lead levels for industrial exposure scenarios.<sup>12</sup> This model is a modification of the Conceptual Model of Lead exposure and bio kinetics in the California Model.<sup>12</sup> The model recognises pica behaviours and practices such as the application of brake fluid as an important exposure pathways for lead exposure.

Three key deliverables have been developed and validated to address exposure issues identified by the model and they include a) a clinical assessment tool for use by health workers to lead exposure levels during pregnancy and after delivery; b) a policy brief to be used as an awareness tool for lead exposure targeted at policy makers in Botswana and; c) an awareness leaflet for pregnant and lactating women on lead exposure. It is worth noting that to develop these documents involved a process of validation by key authorities in Botswana. The validation processes are described as well as a brief introduction to each document which is attached as appendices to this thesis.

## **7.2 THE CLINICAL ASSESSMENT TOOL GUIDELINE**

### *7.2.1 Document development*

This is a mini handbook developed to provide information on lead, its sources, health effects and primary prevention strategies to educate, assess risks and confounders for lead exposure, provide counselling and care during pregnancy and follow-up after delivery (See Appendix 11). Currently alcohol consumption and tobacco use are the only lead related risks (confounders) assessed during pregnancy and included in the obstetric record. Two workshops were organized for health workers at the beginning of the project

and at the end of the project (See appendix 7&8). The first workshop was held in July 2009 prior to recruitment of study participants to raise the level of awareness on lead and its impact on human health and the environment, exposure sources for the general public and pregnant women. The workshop was also intended to introduce the study and its protocols among health workers and the expected inputs from each facility. The workshop targeted senior staff from Sekgoma Memorial Hospital in Serowe and Palapye Primary Hospital in Palapye. Participants included matrons, senior nursing sisters from maternal and child health departments, labour wards, laboratory, theatre and outpatient departments. The Second workshop was held in October 2012 to disseminate the results of the study and to pre-test and validate the clinical assessment tool, the policy brief and the leaflet for pregnant women. This workshop was attended by staff from all the participating health facilities from Lerala, Maunatlala, Sekgoma Memorial and Palapye Primary hospitals. Observations were put together in a workshop report and shared with the participants for feedback. The following sections summarize the observations made at the two workshops

#### *7.2.2 Observations from the first workshop:*

- a) Health workers reported that they were not aware of lead and its impact on human health and pregnancy.
- b) The health workers confirmed that the only risk factors for pregnancy reported in the obstetric record were alcohol and smoking. They also noted that even then these were not associated with lead exposure.
- c) Health workers confirmed that most women ingest soil during pregnancy, however they have associated these with iron deficiency and were not aware that soil ingestion could be a source for lead exposure
- d) Health workers confirmed knowledge of use of substances such as brake fluid and other used car oils, torch batteries by not just pregnant women but the general public for treatment of ringworm, psoriasis including open wounds.

They further revealed that this was not an issue of socio economic status; the products are widely used by population groups across all the social strata.

- e) Health workers endorsed their full support for the study and recommended the following:
- a. That all health workers should be sensitized on lead and its impacts through regular workshops and training
  - b. That the development of guidelines for screening and assessing lead exposure levels will be necessary to guide health workers in the primary prevention of lead exposure during and after pregnancy.
  - c. That the results of the study should be disseminated to policy makers, health workers and the general public to prevent further exposure. They further recommended the development of a policy brief for Government to start thinking lead and its prevention in a broader way
  - d. There was acknowledgement that some cases of lead poisoning could have been misdiagnosed due to the lack of awareness by health care workers

### *7.2.3 Observations from the Second workshop:*

- a) Health workers were given a presentation on the results of the study, which covered the behaviours and practices of pregnant women, the results of environmental lead levels and the results of the blood lead levels and factors associated with blood lead levels. Key issues discussed included pregnant women engaging in multiple risk behaviours such as the ingestion of non-food items by pregnant women, the application of non-conventional skin application items that have not been reported anywhere in the literature such as brake fluid, torch batteries and light brown shoe polish. Some of the health workers acknowledged that they have in fact used some of the products such as shoe polish and brake fluid without the knowledge that they could be exposed to lead.

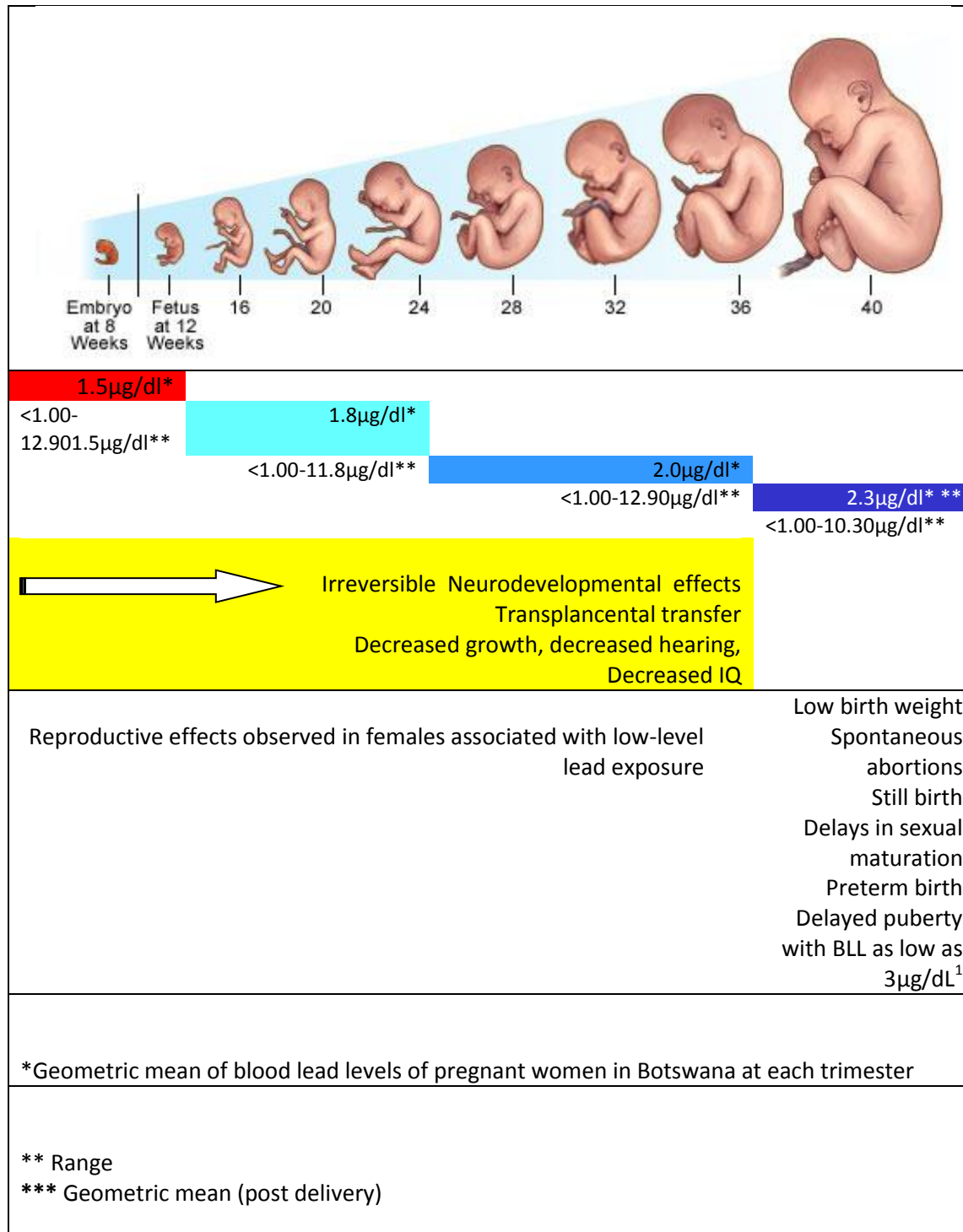
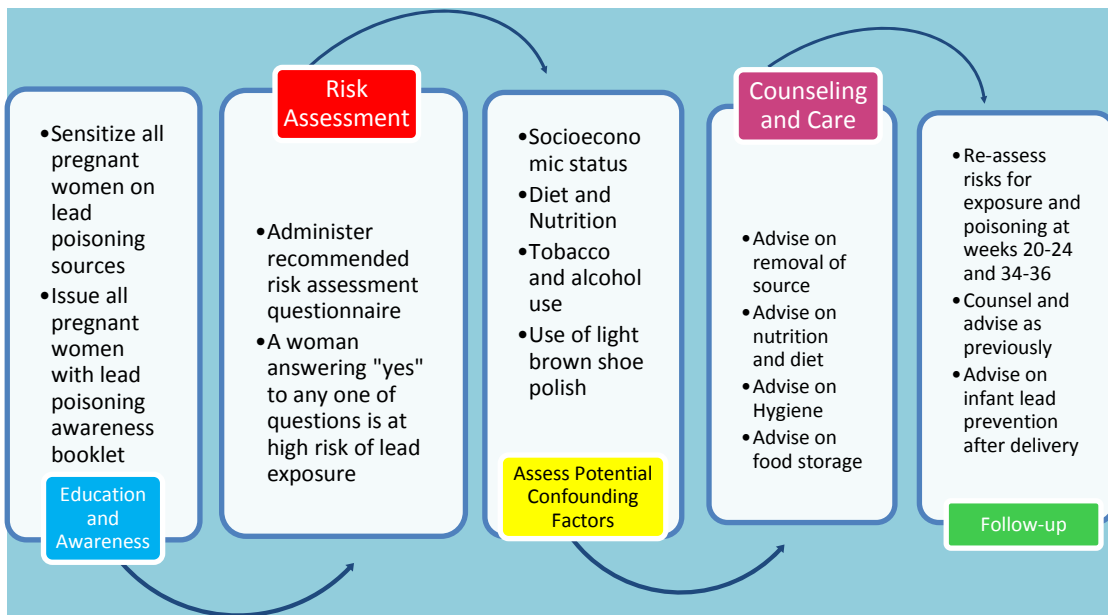


Figure 7.2: Blood lead levels of Pregnant women at each stage of pregnancy, Serowe/Palapye

- b) Health workers were made aware of the fact that despite the pregnant women supplied with calcium, iron and vitamin C supplements during pregnancy they did not utilize the supplements. Some of the reasons for the non-consumption of the supplements were that the women did not like their smell or did not like the taste of the supplements. Others women reported the pills were making them sick.
- c) Health workers were familiarized with the ATSDR diagram as in the clinical assessment tool (Appendix 8) showing blood lead levels associated with adverse health effects for children and adults.
- d) A further visual tool (Figure 7.2) was developed and shared with the health workers, which could be turned into a poster that can be used by health workers as a reference point for blood lead levels at each stage of pregnancy.
- e) A step by step visual summary model guideline (Figure 7.3) for lead exposure assessing was also discussed shared with health workers according health workers an opportunity to understand it and its feasibility. Health workers further proposed that this model guideline could be made into a poster to ensure a quick assessment at the workplace. This model is contained in the screening tool booklet with further explanations.
- f) Health workers were familiarised with the screening tool and had an opportunity to have an input into it as well as the policy brief and the awareness leaflet for pregnant and lactating women.
- g) Health care workers were given an opportunity to give feedback on the draft clinical assessment tool, the policy brief and the awareness booklet for pregnant women. The following feedback was given by the health workers:
  - a. That the clinical assessment document was a good tool, however, they strongly recommended that the risk assessment questionnaires in the tool should be incorporated in the obstetric record as a matter of urgency so that every health workers and the pregnant women can continuously

monitor the behaviour and environmental factors likely to expose pregnant women to lead.

- b. That lead should be included in the curriculum of nursing students and particularly midwives to ensure that every health worker in Botswana is aware of lead, its exposure sources, effects and prevention.
- c. Health worker acknowledged their awareness on pregnant women not consuming the supplements given to them during pregnancy and were aware of the reasons raised by study participants that they do not like the smell and taste of the supplements. They suggested that the supplements should be coated to reduce smell and improve taste
- d. Health workers confirmed other potential household uses of lead such as mending cast iron pots and metal dishes, likely to expose family members to lead.
- e. Education of all health workers on potential lead exposure sources was recommended by the health workers.



**Figure 7.3: Summary model guideline for lead exposure assessment during pregnancy**



### **7.3 POLICY BRIEF PRETESTING AND VALIDATION**

The draft policy brief was presented to the Ministry of Health in October 2012 in a meeting to disseminate the results of the study (See Appendix 10). Key departments/divisions of the Ministry that attended the briefing were Maternal and Child Health, Food and Nutrition and Health Promotion and Education. Participants felt that other Government Ministries such Trade and Consumer Affairs and Environment should be engaged to ensure that they start controlling lead containing materials. The Ministry of Health officials strongly felt that the water authorities should test lead in water and start regulating the use of lead containing material in plumbing pipes and other gadgets. Key recommendations of the policy brief should include lead education in the curriculum of health workers, development of lead surveillance programs, regulation of lead containing plumbing materials and regular testing of drinking water for lead. Finally the Ministry of Health representatives felt that the Botswana Bureau of Standards should be engaged to institute standards that will regulate lead containing materials in Botswana. It was also recommended that even though this study was conducted in the Serowe Palapye District, the results should apply nationally since these practices are observed in all parts of the country. They however recommended a national study to be conducted.

### **7.4 FOCUS GROUP DISCUSSION – AWARENESS BOOKLET**

A group of women who participated in the study were invited to take part in the pretesting of the awareness booklet. The women endorsed the exposure sources listed in the leaflet. They recommended regular education of the general population on lead exposure sources and prevention. They also recommend a campaign to discourage people to use brake fluid oil, torch batteries and other potentially lead containing substances for treatment of skin conditions.

### **7.5 STRENGTH OF THE RESEARCH AND THE DELIVERABLES**

This research has identified the following:

- a) Key lead related behaviours among pregnant women in Botswana

- b) It has generated baseline data on lead levels in pregnant women, which can guide future national studies on lead
- c) Key predictors of lead exposure levels have been identified
  - a. Pica behaviour is well elaborated in Chapter 3 of this thesis
  - b. Lead exposure levels increased by trimester, an important finding that implies the release of lead from bone due to poor diet on the part of pregnant women. This was particularly highlighted from the fact that women from poorer smaller villages had significantly higher lead levels compared to women from the major villages. An interesting finding of this research is that women from Palapye who were expected to have higher lead levels due to living in the vicinity of a mining area, had lower lead levels and this can be apportioned to better living conditions, and better eating habits;
  - c. Multiple risk behaviours which include the use of brake fluid oils, the use of torch batteries, traditional medicines and cosmetic clays are another predictor variable for lead exposure in Botswana.
  - d. Water source and in particular outdoor tap water tap from boreholes is yet another predictor variable for lead exposure. This is well elaborated in Chapter 4, which has revealed that water in the Serowe Palapye area (across all villages) is in excess of the World Health Organisation drinking water quality standards

## **7.6 MAJOR RECOMMENDATIONS:**

These recommendations are informed by the findings of this research as well as the processes that have been discussed above:

- 1) Surveillance on Lead levels in water - Botswana policy issue:

Botswana should initiate the regular testing of water to prevent adverse effects from lead exposure. The regulation of lead containing plumbing materials should be considered as a matter of urgency

- 2) It is recommended that the predictor variables of this work be included in the Botswana Government obstetric record
- 3) Education on lead awareness not only to pregnant women, but other vulnerable groups should be initiated as a matter of urgency
- 4) There is an urgency to implement a national lead surveillance programme in Botswana. It may be useful to make this a regional effort to curb costs as the same problems in Botswana could be experienced in the region

### **7.7 STUDY LIMITATIONS**

This study was intended to cover a major city in Botswana at the initial stages. However due to funding limitations the study focussed in one area, but covered four location of different geographical settings. One which is semi urban (Palapye) the other a typical major village in Botswana and two rural villages. On this basis the author believes the results of this study can be applied to other parts of the country in the absence of a national study.

### **7.8 CONCLUSIONS**

The interventions and the processes discussed in this chapter highlight the importance of this research and have generated interest in the area of lead. An important lesson learnt is that future research should engage the public to gain further insights into research. There is an evident wealth of information in the public that can be tapped through focus group discussions and workshops. For example, the revelation that even health workers engage in some of the habits and behaviours identified in this research would have not been disclosed had the researchers not engaged the health workers. It is also worth noting that health workers in the study area now appreciate the value of research as a tool to improve public health. The researcher also noted an outcry by health workers, and study participants that more often the public scientists carry out research but do not share the results with the public. They expressed their happiness on the extent of the involvement they had in this research from the initial stages to the project completion.

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## Chapter 8:

### GENERAL DISCUSSION AND CONCLUSIONS

#### 8.1: OVERVIEW

The main impetus of this thesis was to develop a clinical screening tool to assess lead exposure during pregnancy and after delivery in Botswana. To arrive at the tool, the author investigated lead exposure among pregnant women from the behavioral, toxicological and environmental perspectives addressed by the different chapters as follows:

Chapter 1 focused on the general introduction to the investigation covering issues of lead sources as well as characterizing the uses of lead and possible exposures in Botswana. The toxicity of lead was discussed in general with highlights on vulnerable groups such as women and children. Special but strong mention is made to the limited research, policies and interventions to address lead in the developing countries. Finally the chapter spells out the rationale for the study and the knowledge it will add to Botswana. There is an acknowledgement in Chapter 1 that newer sources of lead poisoning are emerging. These sources are not well studied and could be detrimental to human health in the context of developing countries. A more holistic approach for assessing lead exposure sources that is not just limited to the traditional lead exposure sources such as paint and occupational sources but explores the cultural and economic setup of the different countries and groupings is suggested.

Chapter 2 presents an in-depth systematic literature review of published scientific reports on uncommon sources of lead poisoning in the general public. The chapter notes one study that has comprehensively reviewed uncommon sources of lead poisoning and therefore attempts to establish the extend of lead poisoning from the non-traditional sources. The main objective of this chapter is to identify population groups at the most risk, commonly reported lead poisoning sources and where these incidents occur. The findings of this chapter proved useful in two ways. First, they highlighted pregnant

women as a vulnerable group to exposure to atypical sources of lead poisoning in the context of the developing world. A good example is that geophagia or intentional ingestion of soil, is a known practice in most developing nations and yet it is not receiving attention in terms of toxic materials exposure. Secondly, the majority of the cases of lead poisoning from exposure to atypical sources occur in the developing world where there are no standards for regulating lead in household products and additionally these cases are only picked in pregnant women when they relocate to the developed countries where there is routine testing of lead exposure for children and pregnant women. Chapter 2 further highlighted the need to assess behavior and practices of different population groups that could potentially expose them to lead such as pica, some cultural practices, as well as socioeconomic factors contributing to lead exposure.

Chapter 3 identifies the prevalence of risk behaviours and practices of pregnant women in Botswana that could potentially expose them to lead during the first trimester of pregnancy. This chapter brings out new knowledge in terms of the behaviours of pregnant women such as the application of brake fluid, torch batteries and shoe polish dermally. The author has not come across any study that has studied the prevalence and predictors of risk behavior for pregnant women in relation to lead exposure. The findings of this chapter have an impact on future policy guidelines for Botswana.

To add to the complex story of potential exposure sources for lead during pregnancy in Botswana, Chapter 4 investigated lead concentrations in soil, water and cosmetic clays and these are compared with international maximum permissible levels. Concentrations of lead in water exceeded the WHO permissible levels and this was identified as a potential source of lead exposure and presents a key policy issue for lead exposure prevention.

Having assessed the behaviours and practices of pregnant women and environmental sources of lead in Botswana, Chapter 5 assesses the baseline concentrations of lead at

each stage of pregnancy. This is not just the first study to measure lead levels over duration of pregnancy in Botswana, but also one of the few studies to achieve this goal regionally. The results indicate a significant increase in blood lead levels at each stage of pregnancy and certainly of clinical importance. Further, this chapter characterizes the women with higher lead levels in terms of their socioeconomic and geographical location. Poorer women who live in small villages were more affected by lead.

Chapter 6 concludes the story by proposing a model for assessing lead exposure levels during pregnancy and after delivery. The model predicts blood lead levels  $\geq 2\mu\text{g/dL}$  in order to develop a clinical assessment tool. Predictor behaviours are pica, multiple risk behaviours, diet, nutrition and socioeconomic factors. The stage of pregnancy was also identified as a risk for lead exposure. This finding is an indicator for lead release from bone and is a crucial finding around which interventions for lead exposure should be developed.

Chapter 7 represents a unique process that led to the development of the clinical screening tool for assessing lead exposure levels, a policy brief and an awareness booklet. It is a representation of the process followed to test the implementation of the protocol. This work therefore not only pieces together a complex story of lead exposure among pregnant women in Botswana, but also achieved the following:

- a) Set the levels in the mother-baby pair
- b) Established the main predictors of lead exposure in Botswana including behavior and practices that are not reported in the current literature such as the use of brake fluid, shoe polish and letsoku and torch batteries.
- c) Implementation of the proposal resulting with three key documents which include; the clinical assessment tool for guiding clinicians and public health professionals, a policy brief for decision makers in Botswana and an awareness booklet which will not only benefit pregnant women but the general population as well.



## 8.2 STRENGTHS AND LIMITATIONS

A notable strength of this work is that it is the first in Botswana to assess lead exposure levels at each stage of pregnancy and after delivery. It is the first to investigate the behaviours and practices of pregnant women that could potentially expose them to lead in Botswana. It is the first to test drinking water as a potential source of lead exposure in Botswana and most importantly, it is the first to deliver a pragmatic lead exposure screening and assessment tool for health professionals and a policy brief to facilitate information dissemination on the problems posed by lead to public health for policy makers. The study developed an empirically based conceptual framework for predicting lead exposure in an inclusive manner taking into account multiple levels of sources and exposure.

A further strength of this study was that it has combined the qualitative and quantitative methods to provide an overall picture of the behaviours, practices of pregnant women and lead concentrations in blood and environmental medium. The quantitative data offered a valuable picture of what and how much of lead from the different sources, while the qualitative data explained where the lead levels would be more prevalent and why it would affect a certain group of pregnant women more than the other/s. Clearly the two methods were complimentary to each other

The weakness of this study design is that it focused on major and rural villages and therefore misses the component of areas that are fully urbanized in Botswana. The study could also not provide information on the knowledge and attitudes of women on lead and its exposure sources. It therefore makes assumptions that women were not knowledgeable on lead and its sources.

As a result of the loss to follow up, the number of women who completed the study (first trimester until after delivery) was small. The limited resources also contributed to a small sample size of environmental samples.

Despite the limitations, the study design offered sufficient information to enable the findings to be applied to many districts in Botswana if not nationally. It is acknowledged that these findings may not entirely be applied to the cities in Botswana because of the socio economic reasoning. The services and the infrastructure in the cities are entirely different. For example the cities are not serviced with borehole water while major and rural areas are serviced with such.

### **8.3 GENERAL RECOMMENDATIONS**

The implications of the findings of this work are discussed in detail in the different chapters and therefore to avoid repetitions, the reader is referred to the summaries and conclusions made at each chapter.

#### *8.3.1 Public Awareness on Lead Hazards*

There is a need to initiate public awareness programs that will not only target pregnant women, but the general public. The rationale for this is that some of the practices and behaviours of pregnant women may affect other family members. As reflected in the literature some of the lead poisoning sources, particularly at household level may have an impact on the rest of the family (refer to chapter 2). Typical examples are folk remedies and utensils used at the household level that may contain lead. Furthermore, this study has shown that despite an extensive and growing global body of knowledge of the health and social hazards of lead, there is limited awareness in the general public in Botswana. This is evidenced by the practices and habits of pregnant women reported in Chapter 3 of this work. Particular attention should be paid to poorer communities. The booklet developed from this work should be translated into Setswana to accommodate members of the public who could not read English.

#### *8.3.2 Health Worker Training:*

Health workers are agents of change and therefore should be equipped with knowledge to facilitate change. Evidently, the feedback from health workers during the study

workshops (refer to Chapter 7) showed little awareness on lead and its impacts on public health or the sources and mechanisms of exposure to lead. This was reflected by their responses and the interest they showed in the study. Every health worker in Botswana should be familiarized with the contents of the clinical assessment tool for lead exposure regardless of whether they are based in rural or major villages or the cities and towns in Botswana. The rationale for this is that naturally Botswana have three homes, the lands/fields, the home village and the workplace, which could be a village or a city. Additionally, health workers who work in Government facilities may be transferred to the rural/small or major villages or towns or cities. Consistency of information is therefore important.

### *8.3.3 Policy Options for Botswana*

To address the gaps in this study, it is recommended that the Government of Botswana initiate a national lead surveillance programme to identify the key sources of lead, the mechanism of exposure and related risk factors for lead exposure. It is further recommended that the obstetric record booklet be reviewed to incorporate potential risk factors for lead exposure. Finally Botswana Government is encouraged to follow the international world and start regulating lead containing materials for plumbing as well as imported lead containing household products. These are well elaborated in the policy brief (Appendix 8). The good news is Botswana is already doing some of the required primary prevention strategies for lead exposure such as supplying pregnant and vulnerable groups with food supplements (without knowing that it is a lead prevention measure), the setback is that there is no follow-up to establish if pregnant women use the supplements (refer to Chapter 5 and 6). There is therefore a need for Botswana to carry out research that will establish why pregnant women do not take supplements as prescribed. Informal discussions with respondents revealed that they do not take them because of unacceptable odour. This is a policy issue needing investigation. For example it would save government money perhaps to consider discussing with manufacturers that

the supplements be coated to reduce the strong odour. This will go a long way in protecting public health and in particular maternal and child health

#### *8.3.4 Development of a Criterion for Lead testing during Pregnancy*

Finally, there is currently no lead testing or standards for any population grouping in Botswana. This study reveals the pregnant woman as a source of lead exposure for babies who are not yet born. It is perhaps time for Botswana to consider developing a criterion for lead testing during pregnancy. Throughout this thesis it has become evident that prenatal lead exposure to lead is a cause for concern. The stage of pregnancy as a predictor for lead exposure is a matter that should be taken seriously. Even though the lead levels are low in this study, literature (as cited in all the chapters of this thesis) show that waiting for levels that are higher may cause irreversible damage to the developing brain of the child. No country with an intention to protect and to preserve public health can wait to see the symptoms to check lead exposure any longer. Chapter 2 of this thesis has shown that chelation therapy is not the solution, but education and awareness, the removal of the sources of lead poisoning, good diet and nutrition are better solutions to lead management.

### **8.4 DIRECTIONS FOR THE FUTURE**

8.4.1 The results of this thesis have been shared in a national workshop (Appendix 9) as well as to the Ministry of Health program officers, and local health workers in the study areas (Appendix 8). It is the intention of the author of this thesis to follow up on the recommendations of this work and use this work to foster more collaborative work with scientists in the region to elevate lead exposure as a problem likely to affect the current and future generation in the developing world as reflected in chapter 2 of this thesis.

8.4.2 There is need for more research on lead poisoning and lead exposure sources in Botswana. This is given the fact that lead containing materials are not regulated in Botswana and given the fact that household members purchase lead solder for different

purposes including mending cooking and eating utensils. These and many other concerns require further investigation.

8.4.3 The utility of the clinical assessment tool developed in this research should be tested and evaluated. This can only be done if awareness on the tool is created and thus the tool is utilized in health facilities. The need to publicise the tool is therefore identified.