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Cadmium, lead and mercury exposure in non smoking pregnant women

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ABSTRACT

Recent literature suggests that exposure to low concentrations of heavy metals may affect both maternal and child health. This study aimed to determine the biological heavy metals concentrations of pregnant women as well as environmental and dietary factors that may influence exposure concentrations. One hundred and seventy three pregnant women were recruited from Western Australia, each providing a sample of blood, first morning void urine, residential soil, dust and drinking water samples. Participants also completed a questionnaire which included a food frequency component. All biological and environmental samples were analysed for heavy metals using ICP-MS. Biological and environmental concentrations of lead and mercury were generally low (Median Pb Drinking Water (DW) 0.04 μg/L; Pb soil <3.0 μg/g; Pb dust 16.5 μg/g; Pb blood 3.67 μg/L; Pb urine 0.55; μg/L Hg DW <0.03; Hg soil <1.0 μg/g; Hg dust <1.0 μg/g; Hg blood 0.46 μg/L; Hg urine <0.40 μg/L). Cadmium concentrations were low in environmental samples (Median CdDW 0.02 μg/L; Cdsoil <0.30 ug/g; Cddust <0.30) but elevated in urine samples (Median 0.55 μg/L, creatinine corrected 0.70 μg/g (range <0.2–7.06 μg/g creatinine) compared with other studies of pregnant women. Predictors of increased biological metals concentrations in regression models for blood cadmium were residing in the Great Southern region of Western Australia and not using iron/folic acid supplements and for urinary cadmium was having lower household annual income. However, these factors explained little of the variation in respective biological metals concentrations. The importance of establishing factors that influence low human exposure concentrations is becoming critical in efforts to reduce exposures and hence the potential for adverse health effects.

1. Introduction

The persistent heavy metals cadmium (Cd), lead (Pb) and mercury (Hg) are ubiquitous contaminants that accumulate in the environment through natural occurrence and widespread anthropogenic and industrial use. These heavy metals have been found in contaminated food, drinking water and soils resulting in human exposure and in some cases adverse health effects (Järup, 2003). The risks of exposure to high concentrations of Cd, Pb and Hg are well understood and have been extensively investigated over the past two decades. However, recent research suggests that exposure concentrations previously considered safe now present risks to vulnerable members of society and in particular children (Lanphear et al., 2000; Sanders et al., 2012; Shirai et al., 2010; Xie et al., 2013).

Heavy metals have been associated with a number of health effects in children and adults. Cadmium exposure has been associated with a variety of health effects including skeletal damage, neurological effects and kidney damage (Akesson et al., 2006; Alfvén et al., 2000; Grandjean et al., 1999; Järup, 2003; Järup and Alfvén, 2004; Satarug et al., 2010). High lead exposures have been associated with hypertension, diabetes, gastrointestinal problems and neurological effects (Jedrychowski et al., 2008, 2009). Mercury exposures have also been associated with neurological impacts and renal disease (Jedrychowski et al., 2006; Oken et al., 2005, 2008).

Maternal exposure to the heavy metals lead and mercury represents a significant source of exposure to the developing child (Röllin et al., 2009; Shirai et al., 2010) and pregnant women are

Abbreviations: DL, Detection limit; MDL, Method limit of detection.
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considered a vulnerable group to heavy metals exposures for themselves and, in the case of mercury and lead, as a source of exposure for their children because of placental transfer (Shirai et al., 2010; Silbernagel et al., 2011). Maternal blood mercury and lead concentrations readily transfer across the placenta to the developing foetus (Röllin et al., 2009; Al-Saleh et al., 2011). By contrast, studies investigating prenatal cadmium exposure indicate that maternal blood cadmium does not readily transfer across the placenta (Odland et al., 1999; Salpietro et al., 2002). However iron deficiency during pregnancy has been implicated in increases in Cd accumulation in pregnant women which may affect the growth of the child (Björkman et al., 2000; Lin et al., 2011). Increased maternal cadmium concentrations may increase the risks of adverse health outcomes in both mothers and children, with risks to infants of reduced foetal growth potentially mediated by alterations in placental gene expression (Akesson et al., 2002; Nishijo et al., 2004; Yang et al., 2006; Shirai et al., 2010).

The reported effects of prenatal exposure to lead are delayed development outcomes, reduced cognitive functioning, reduced motor skills and decreased language, learning and memory skills (Canfield et al., 2003; Lanphear et al., 2005; Miranda et al., 2011; Silbernagel et al., 2011). Methylmercury exposure in pregnant women has been associated with a variety of adverse neurobehavioural outcomes in children where very low concentrations have been reported to result in memory deficits and developmental delays (Grandjean et al., 1999; Jedrychowski et al., 2006).

Although specific point sources of pollution, smoking or occupational activities can increase exposure to heavy metals, dietary intake, including consumption of drinking water, is recognised as being a significant contributor to human exposure in the wider community (ATSDR, 1999; Oskarsson et al., 2004; Ryan et al., 2001; Wilhelm et al., 2002). Diet has been shown to have a significant influence on maternal urinary cadmium concentrations (Nishijo et al., 2004).

Many studies have reported concentrations of heavy metals in blood and urine of pregnant women as both an indicator of risk to unborn children and also to establish factors that have influenced increased exposure(Kippler et al., 2012; Lanphear et al., 2005; Jedrychowski et al., 2006, 2008; Sanders et al., 2012). While many of these studies report predictors of biological concentrations, few have combined environmental, biological and questionnaire and food frequency questionnaires to assess the significance of predictors of exposures in non exposed pregnant women. Sanders et al., 2012 reported age, geographical residence and race as factors that predicted biological heavy metals concentrations. The NHANES survey (Jain 2013) reported parity and smoking to be associated with increases in urinary lead, age with increased urinary cadmium, while shellfish/fish intake increased mercury concentrations, as also reported in many other studies (Miranda et al., 2011). Age, gender and smoking have also been shown to influence urinary metals concentrations with women having increased urinary cadmium concentrations (Järup 2003; Röllin et al., 2009; Vahter et al., 2007). Lower socioeconomic status has also been associated with higher lead concentrations (Lanphear et al., 2000).

Given the potential for adverse health outcomes at lower concentrations of exposure, it is essential that predictors of exposure are better defined to identify sources and activities with a view of minimising the potential for adverse health effects in women and children.

This study aimed to investigate maternal exposure to lead, mercury and cadmium in non-occupationally exposed, non smoking pregnant women in Western Australia, where there are limited point sources of pollution. Blood and urine concentrations are reported as well as the relationships between environmental, dietary and other factors influencing exposure concentrations.

2. Materials and methods

2.1. Study design

A cross sectional study of heavy metal exposure in non smoking pregnant women aged greater than 18 years in Western Australia (WA). Participants provided both biological and environmental samples as well as completing a questionnaire including questions on diet, hobbies and lifestyle.

This study received ethics approval from the Edith Cowan University Human Research Ethics Committee, WA Country Health Service, St John of God (Subiaco and Bunbury), Joondalup Health Campus and King Edward Memorial Hospital Ethics Committees. All participants in this study provided written informed consent.

2.2. Study population and recruitment

Participants were recruited from across the State in and around the towns of Esperance, Albany, Bunbury, Busselton, Margaret River/Dunsborough, Bridgetown/Nannup, Collie, Geraldton, Port Hedland, Kalgoorlie and Perth (Fig. 1) between 2008 and 2011.

Recruitment was undertaken by approaching GPs and community health centres, attending antenatal classes and providing information at shopping centres, farmers markets and local events as well as local media to advertise the study and interest potential recruits. Of 363 women who enrolled in the study, 173 (48%) completed the study protocol including the provision of biological and environmental samples, the remaining women failed to complete the protocol. Of all pregnant women in the study regions over the study period this represented a recruitment fraction of less than 1%.

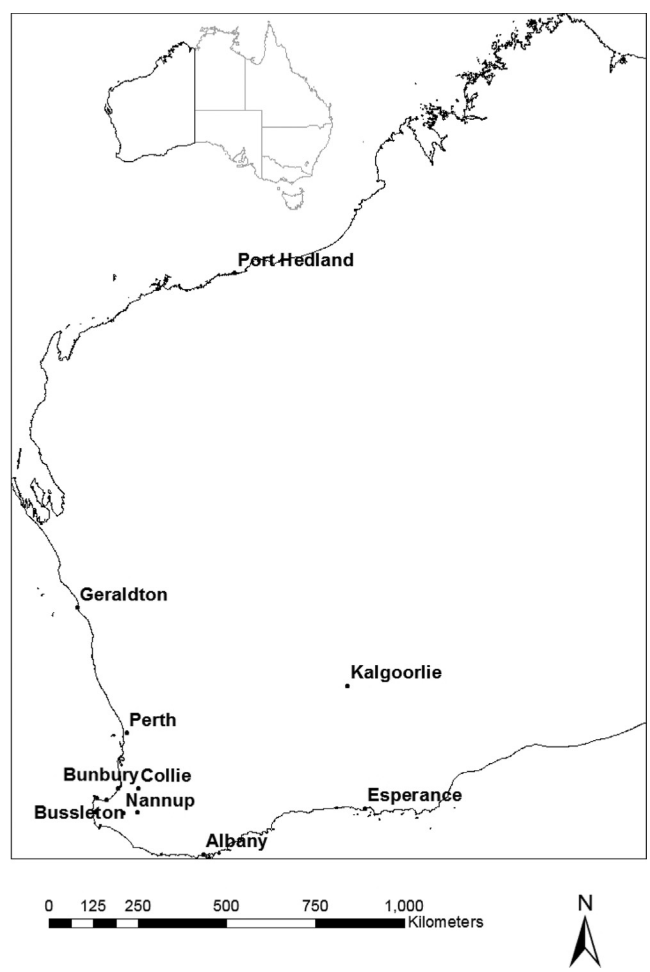

Fig. 1. Study areas.