Presentation to the Fingerboards IAC

Professor Helena C. Parkington

My Expertise

Bachelor of Pharmacy

- Develop drugs to cure disease
- Effects of drugs as poisons (forensic pharmacy)
- Pharmaceutical industry – Quality control

Bachelor of Science

- Teaching and research

Doctor of Philosophy

- Research heart and artery disease
- Pregnancy – mum and baby

Fetal origins of adult disease

Events in early life can impact long-term health in humans

Low birth weight is a risk factor for heart disease in adults

Concept developed by David Barker FRS and colleagues at University of Southampton through landmark papers:

Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. *Lancet*, (1986) **1:** 1077–1081

Trajectories of growth among children who have coronary events as adults. *New England Journal of Medicine* (2005) **353:** 1802-9

Mechanisms of disease: *in utero* programming in the pathogenesis of hypertension. *Nature Clinical Practice Nephrology* (2006) **2:** 700-707.

Early onset of coronary artery disease after prenatal exposure to the Dutch famine (2006) *American Journal of Clinical Nutrition* **84**: 322-7

Fetal origins of adult disease

Related studies by Parkington and colleagues at Monash University: 28 papers.

Maternal obesity in pregnancy: Consequences for brain function in the offspring. *Prenatal and Postnatal Determinants of Development.* (2016) Humana Press, New York, Ch 10: 203-219

Accelerated age-related decline in renal and vascular function in female rats following early life growth restriction. (2015) *Am J Physiol: Regul, Integr, Comp Physiol*. **309**: R1153-1161

Maternal melatonin administration mitigates coronary stiffness and endothelial dysfunction, and improves heart resilience to insult in growth restricted lambs. (2014) *J Physiol*. **592**:2695-709

Maternal alcohol consumption in pregnancy enhances arterial stiffness and alters vasodilator function that varies between vascular beds in fetal sheep. (2014) *J Physiol*. **592**:2591-603

Exposure to intrauterine inflammation leads to impaired function and altered structure in the preterm heart of fetal sheep. (2014) *Clin Sci*. **127**:559-69

Vitamin D insufficiency is associated with impaired vascular endothelial and smooth muscle function and hypertension in young rats. (2011) *J. Physiol*. **589**:4777-4786

Intrauterine growth restriction delays cardiomyocyte maturation and alters coronary artery function in the fetal sheep. (2007) *J. Physiol*. **578**:871-881

Fetal origins of adult disease

Conclusions:

Hundreds of articles have been published that report associations between a wide variety insults/trauma at the fetal/perinatal/infant stage of development, and a wide and heterogeneous range of health outcomes in later life, including:

High blood pressure	diabetes	kidney disease
obesity	osteoporosis	cognitive development
cancer	stroke	coronary artery disease (CAD)

Autism spectrum disorders (ASD) (largest expenditure by the NDIS - 30%)

Fetal origins of adult disease

Relevance to the EES

A significant insult/trauma at the fetal/perinatal/infant stage of development from mining is dust, including particulate matter PM2.5

No evidence that the Proponent will be able to suppress dust adequately

No evidence that the Proponent can measure dust adequately

- *see* 38 Appendix A009, p.22, by Katestone

Thus, significant gaps in the background dataset for respirable crystalline silica (RCS) which occur late summer early autumn.

Climatic conditions during this period likely to give higher levels of dust and associated RCS.

Ecotech is not NATA accredited for a number of the methods used in the background monitoring. This particularly applies to small particles - PM2.5.

Impact of particulate matter:

Importantly:

- Pregnant women and their unborn infants are among the groups most vulnerable to PM2.5.
- PM2.5 can cross the blood-placental barrier and circulate in fetal blood.
- Infants are more susceptible to PM2.5 exposure than are adults.
- Consequences for the offspring are a lifetime sentence of suboptimal health with associated increased morbidity and health costs for the individual and society.

Perinatal health impact of particulate matter:

Importantly:

Early life exposure to air pollution induces adult cardiac dysfunction. (2014) *American Journal of Physiology-Heart and Circulatory Physiology* **307**: H1353-H1360

Autism spectrum disorder and air pollution: A systematic review and meta-analysis. (2021) *Environmental Pollution* **278:** 116856

Effect of PM2.5 pollution on perinatal mortality in China. (2021) *Scientific Reports* **11:** 7596

Maternal exposure to ambient fine particulate matter and fetal growth in Shanghai, China. (2019) *Environmental Health* **18:** 49

Children's microvascular traits and ambient air pollution exposure during pregnancy and early childhood: prospective evidence to elucidate the developmental origin of particle-induced disease. (2020) *BMC Medicine* **18:** 128

Particulate matter, an intrauterine toxin affecting fetal development and beyond. (2021) *Antioxidants* **10:** 732

Developmental programming of obesity by maternal exposure to concentrated ambient PM2.5 is maternally transmitted into the third generation in a mouse model (2019) *Particle and Fibre Toxicology* **16:** 27

Health impact of particulate matter:

Importantly, crustal dust PM2.5 has similar adverse health impacts to other sources:

A comparison of the health effects of ambient particulate matter air pollution from five emission sources. (2018) International Journal of Environmental Research & Public Health **15:** 1206

Finer and coarser PM also has adverse health effects:

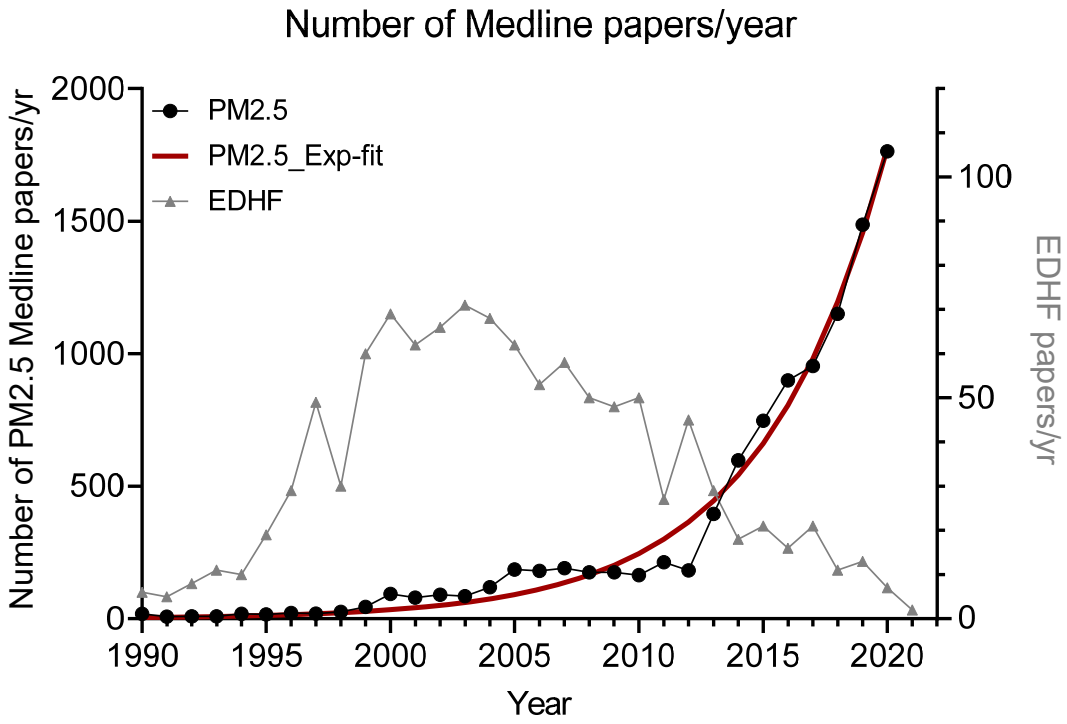
Ambient ultrafine particle concentrations and incidence of childhood cancers. (2020) Environment International 145: 106135 (<0.1 um)

The effects of Port Hedland crustal dust on lung cell biology. (2009) Report to Department of Jobs, Tourism, Science and Innovation, WA. (PM10)

Port Hedland air quality health risk assessment for particulate matter. (2016) Report by Environmental Health Directorate, Department of Health, WA.

- *"increasing concentrations of PM10 at any level is associated with increased levels of acute and chronic respiratory and cardiovascular health effects"* p. 33.
- *"There remains insufficient evidence in the literature to differentiate between the toxicity of the PM10 in Port Hedland and the PM10 from large urban centres."* p. 33.

Health impact of particulate matter:



Scientific studies on the health issues associated with PM2.5 are increasing exponentially.

70% of all papers were published in the last 5 years

Indicative of our limited knowledge - much still to learn

Implications about relevance of current dust levels deemed safe. Supported by a French study

Health impact of particulate matter:

Maternal ambient exposure to atmospheric pollutants during pregnancy and offspring term birth weight in the nationwide ELFE cohort. (2021) *International Journal of Environmental Research and Public Health 18: 5806* (French study of 13,334 women in urban and rural locations)

"5. Conclusions

Among a population of women with average exposures to $PM_{2.5}$, PM_{10} and NO_2 below the current European air quality standards of 25, 40 and 40 µg/m^3, respectively, this nationwide study suggests an adverse effect of exposure to these pollutants during the second trimester and first half of the third trimester of pregnancy on the birth weight of the baby at term."

Levels of particulate matter:

Australian national standards for particulate matter:

The National Environment Protection Council (NEPC) approved in Dec 2015 the following Ambient Air Quality NEPM standards for particulate matter:

		From 2015	Goal from 2025	Kalbar EPA 2007 used
		µg/m^3	µg/m^3	µg/m^3
Particles as PM_{10}	1 day	**50**		**60**
	1 year	25		
Particles as $PM_{2.5}$	1 day	**25**	**20**	**36**
	1 year	8	7	

- Air quality standards similar or higher PM levels than European levels.
- Victorian ambient air quality failed to meet these standards at every monitoring station during 2018 and 2019 (Vic EPA reports on compliance with NEPM AAQ)
- In recognition of health issues, NEPC goal is to reduce $PM_{2.5}$ standard to 20 µg/m^3 by 2025 (very early stage of the proposed mine)
- 70% of $PM_{2.5}$ health literature published since the standards were determined
- **Feasible to meet current standard or 2025 goal with an upwind open cut mine?**

Health impact of particulate matter:

Perspective: Particulate matter, an intrauterine toxin affecting fetal development and beyond. (2021) *Antioxidants 10: 732* (by Poronnik and colleagues, UTS & Univ Syd)

Conclusions:

"This perspective summarises currently available evidence, which suggests that intrauterine exposure to PM2.5 promotes oxidative stress and inflammation in a similar manner as occurs in response to direct PM exposure."

" it is increasingly recognised that long-term exposure to even low level of PM (quite often considered as "safe level") increases the risk of disorders in vital organ systems, including the heart, the lung and the brain…. Although not widely studied, PMs are now considered an *in utero* environmental toxin…. Here, we summarised the currently available evidence from a limited number of publications to raise the awareness of the needs for more comprehensive research into this currently understudied yet important health topic."

Health impact of maternal exposure to heavy metals:

Association of biomarkers of exposure to metals and metalloids with maternal hormones in pregnant women from Puerto Rico. (2021) *Environment International 147: 106310* (16 metalloids)

"In summary, our study is the first to assess associations between prenatal sex-steroid hormones and metal(loid)s exposure."

"It is known that As is transported through the placenta, possibly by GLUT1, one of the main transplacental glucose transporters (Jones et al., 2007). Experimental data suggest that As interferes with the glucocorticoid receptor signaling system (GR) in both the placenta and the fetal brain." As is in high concentrations in the Fingerboards area.

"Arsenic … significantly associated with increased levels in CRH ….. and decreased levels in testosterone."

"*Conclusion:* Our analysis suggests that metal(loid)s may act as endocrine disruptors by altering prenatal hormone levels."

"The study of metal(loid)s as endocrine disruptors is in the early stages of epidemiological research and future studies are needed to further investigate these associations."

"The prenatal hormonal milieu is a critical component for fetal growth and development which contribute to children's later health and disease risk, and ultimately public health."

Health impact of maternal exposure to heavy metals:

Pregnant Inuit women's exposure to metals and association with fetal growth outcomes: ACCEPT 2010–2015. (2019) *International Journal of Environmental Research and Public Health 16: 1171*

Maternal blood anayzed for 13 metals. Various parameters of fetal growth analysed.

Conclusions: "Heavy metals in maternal blood can adversely influence fetal development and growth in a dose–response relationship."

Consistent with their references 23, 25-29.

Developmental neurotoxicity of arsenic: Involvement of oxidative stress and mitochondrial functions. (2018) *Biological Trace Element Research* **186**:185–198

" our results indicate that perinatal arsenic exposure leads to abrupt changes in ROS, oxidative stress, and mitochondrial functions and that apoptotic factor in different brain regions of rats might contribute to this arsenic-induced developmental neurotoxicity."

Health impact of maternal exposure to heavy metals:

Review: Early-life exposure to Endocrine Disrupting Chemicals and later-life health outcomes: An epigenetic bridge? (2014) *Aging and disease* **5:** 419-429

EDCs considered to include heavy metals.

"recent research findings indicate that exposure to EDCs during in-utero and/or neonatal development can cause long-term health outcomes via mechanisms of epigenetic memory."

Inorganic arsenic induces sex-dependent pathological hypertrophy in the heart. (2021) *Am J Physiol Heart Circ Physiol* **320:** H1321–H1336

"iAS induced similar hypertrophic gene expression changes in neonatal rat ventricular myocytes … As such, these results highlight iAS exposure as an independent cardiovascular risk factor and provide biological impetus for its removal from human consumption."

Sources of heavy metals:

Dust, including $PM_{2.5}$ and PM_{10} can enter the body by: ingestion, inhalation, and dermal contact. Dust can enter houses and schools where it is of particular concern for children.

A review of heavy metals in indoor dust and its human health-risk implications. (2016) *Rev Environ Health* **31:** 447–456

"The US EPA has classified indoor air as requiring attention as it is more contaminated in comparison to outdoor air."

"Studies have shown that indoor dust acts as a carrier of inorganic and organic pollutants such as heavy metals, pesticides, polychlorobiphenyls and polycyclic aromatic hydrocarbons."

"Amongst other pollutants in indoor dust, heavy metals require crucial study due to their non-degradable properties, high toxicity and adverse effects on humans."

"Children are also more vulnerable to heavy metals in indoor dust due to their behaviour such as crawling, hand-to-mouth activities and fast growth rate."

" ingestion of dust is the main heavy metal exposure pathway for children as children tend to play on the floor and ingest the dust indirectly."

Heavy metal standards

3.2.1 HIL A values – residential land use scenario with garden/accessible soil

"This land use scenario assumes typical residential properties, consisting of single storey dwellings supported by ground-level slabs or multistorey dwellings where living areas are on the ground floor and there is accessible soil in the front and backyard areas."

RECEPTORS	EXPOSURE PATHWAYS	
A Adult residents B Child residents (0 - 6 years)	1 Indoor inhalation of vapours derived from shallow soil 2 Outdoor inhalation of vapours derived from shallow soil 3 Incidental ingestion of surface soil and dust particulates 4 Dermal contact with surface soil and dust particulates 5 Indoor inhalation of dust particulates	6 Outdoor inhalation of dust particulates 7 Consumption of home-grown produce 8 Consumption of soil adhering to home-grown produce

Figure 1. CSM for HIL A – standard residential land use scenario with garden/accessible soil

Sources of heavy metals:

Drinking water:

Tank water

Dust, including $PM_{2.5}$ and PM_{10}, contaminated with heavy metals, that lands on house roofs will end up in household tank drinking water. This will affect numerous farms downwind of any potential mining site.

Town water

Located only a few kms downwind.

Sources of heavy metals:

Consumption of contaminated food:

Wind-blown contaminants from the mine would likely settle on the vegetables.

Vegetables can uptake these heavy metals from:

Their leaves

The soil

These heavy metals cannot be washed off the vegetables since they are inside the cells

The uptake and bioaccumulation of heavy metals by food plants, their effects on plants nutrients, and associated health risk: a review. (2015) *Environ Sci Pollut Res* **22:** 13772–13799

"The literature about heavy metals in food plants shows that both leafy and nonleafy vegetables are good accumulators of heavy metals. In nonleafy vegetables, the bioaccumulation pattern was leaf > root ≈ stem > tuber."

"Vegetables are the major source of human exposure to heavy metal and contribute about 90 % of the total metal intake …"

Sources of heavy metals:

Association between heavy metals and metalloids in topsoil and mental health in the adult population of Spain. (2019) *Environmental Research* **179:** 108784

"Conclusions: Living in areas with a higher concentration of heavy metals and metalloids in soil was associated with an increased probability of having a mental disorder. These relationships were strengthened in individuals reporting consuming vegetables > once a day."

Bioaccumulation and Health Risk Assessment of Heavy Metals in the Soil–Rice System in a Typical Seleniferous Area in Central China. (2019) Environmental Toxicology and Chemistry **38:** 1577–1584

"Soils were contaminated by Mo, Cu, As, Sb, Zn, Cd, Tl, and Hg. The high hazard quotients of Mo (1.97 ± 1.47) and Cd (5.22 ± 5.02) suggested a high risk of Cd and Mo for Enshi residents through consumption of rice."

"A nationwide survey has shown that 19% of China's agricultural soils have been contaminated with heavy metals to varying degrees (Wang et al. 2014). This is of great concern because heavy metals cause adverse effects on human health and ecosystems."

Acrylamide: Adverse health effects:

Review: Polyacrylamide degradation and its implications in environmental systems. (2018) *Clean Water* **1:** 17

Review: Acrylamide: A review about its toxic effects in the light of Developmental Origin of Health and Disease (DOHaD) concept. (2019) *Food Chemistry* **283:** 422–430

"Acrylamide is considered a potential EDC" (endocrine-disrupting chemical)

Prepubertal acrylamide exposure causes dose-response decreases in spermatic production and functionality with modulation of genes involved in the spermatogenesis in rats. (2020) Toxicology 436: 152428

"This study is the first one … to correlate the AA exposure with puberty development, as well as the AA-induced endocrine disrupting effects on reproductive axis…… AA reduces spermatogenesis, induces morphological and functional defects on sperm and alters transcript expression of sexual hormone receptors.

These findings suggest that excessive AA consumption may impair their reproductive capacity at adulthood, despite no changes in hormonal profile being observed."

Conclusions

The proposed mine poses a significant health hazard through wind-blown dust containing $PM_{2.5}$ and PM_{10} matter, worsened by contaminating heavy metals.

- Abundant scientific literature on the numerous adverse effects on adults
- Significant effects on fetuses and young children at critical developmental stages
- Through fetal origins, the offspring, their families, and society will have to live with and

pay for the consequences for the lifetime of affected individuals.

Evidence of adverse effects at ambient dust levels below current standards.

The Proponent used earlier standards with higher PM levels to assess the adverse health effects.
Implications for health effects, level of dust suppression, and water usage for dust suppression.

Current standards for PM date from 2015, before 70% of the scientific literature was published.

Heavy metal standards, HIL A, refers to a residential house on shallow soil contamination -
Not to large clouds of contaminated dust blowing off an open-cut mine site.

NEPM 2013, Vol 19, Schedule B7

Conclusions

The home is not a haven – evidence indicates heavy-metal contaminated dust is worse inside buildings such as houses, schools.

Despite the major health issues of dust, particularly on forthcoming generations:

- No evidence that the Proponent:

  Is able to suppress dust adequately

  Will adequately measure dust levels (current monitoring site is not a "representative measure of the air quality likely to be experienced by the general population in the region or sub-region" (NEPC – AAQ)

- The monitoring equipment failures, low quality, and lack of robustness in results and conclusions at this early, critical stage of close scrutiny does not auger well for future monitoring of dust etc if mining given approval.

- Overall, there are huge uncertainties about dust suppression, long term health effects of the dust and heavy metals, and major implications for the various agricultural industries:

  All of this for minimal gain.