

An investigation of the effects of lead on children's cognitive abilities

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Amendments to Thesis

- On page 7, changed “plumbumb” to “plumbum”.
- Page 13, changed second “summer” to “winter”.
- Page 14 – deleted “but non-nutritive ingestion is viewed as the primary source of Pb exposure for both adults and children”.
- Page 19- included mention of x-ray fluorescence as a measure of bone lead.
- Corrections made to Table 30 – gravidity and mode of delivery corrected to add to 100%.
- Page 275 added: “The likelihood that speed of information processing is important as demonstrated by these psychometric evaluations is also supported by previous investigations of the associations between nerve conduction velocity and Pb exposure (Araki & Honma, 1976; Feldman, Haddow, Kopito & Schachman,1973; Landrigan, Baker Jr., Feldman, Cox, Eden, Orenstein, et al.,1976).”
- Page 110 added: “Firstly, it is noted that in Australia primary Pb exposure pathways are likely to have changed since the collection of Donovan and Anderson’s (1996) data due to the eradication of leaded petrol. Regrettably no national evaluation of Pb exposure in Australia was conducted before or subsequent to Donovan and Anderson’s (1996) work. In the absence of updated data, estimates of numbers of population affected by Pb exposure are crude.”

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Acronyms and abbreviation

AAIDD	American Association on Intellectual and Developmental Disabilities
ABS	Australian Bureau of Statistics
AEDI	Australian Early Development Index
APS	Australian Psychological Society
ACHIV	Achievement standard score
ADHD	Attention-Deficit Hyperactivity Disorder
ANZSCO	Australian and New Zealand Standard Classification of Occupations
BAS	British Ability Scales
BDI-II	Beck Depression Inventory - Second Edition
BoD	Burden of Disease
BOM	Australian Government Bureau of Meteorology
B-OTMP	Bruininks-Oseretsky Test of Motor Proficiency
BSID	Bayley Scales of Infant Development
BWRT	Burt Word Reading Test
CDC	The United States Centers for Disease Control and Prevention
CHC	Cattell-Horn-Carroll model of intelligence
CI	Confidence Interval
CLS	Cincinnati Lead Study
CNS	Central nervous systems
Cp	Process Capability
CPM	Raven's Coloured Progressive Matrices
CPT	Continuous Performance Test
DAS	Dyadic Adjustment Scale
DNA	Deoxyribonucleic acid
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th. Edition.

DSOP	Daniel's Scale of Occupational Prestige
EFC	Plasma-extracellular fluid
EPA	United States Environmental Protection Agency
FSIQ	Full Scale IQ
FWS	Filtered Word Subtest
g	General intelligence
Ga	Auditory processing
Gc	Crystallised intelligence
GCI	General Cognitive Index
Gf	Fluid reasoning
Glr	Long-term storage and retrieval
Gs	Speed of information processing
Gsm	Short term memory
Gv	Visuo-spatial ability
HOME	Home Observation for Measurement of the Environment Inventory
IT	Inspection Time
ITPA	Illinois Test of Psycholinguistic Abilities
K-ABC	Kaufman Assessment Battery for Children
KBIT	Kaufman Brief Intelligence Test
KEDI-WISC	Korean Educational Development Institute – Wechsler Intelligence Scales for children
KID	Kent Infant Development Scale
K-TEA-BF	Kaufman Test of Educational Achievement – Brief Form
K-X-ray	K line X-ray fluorescence
MC HOME	Middle child Home Observation for Measurement of the Environment Inventory
MDI	Mental Development Index

MFC	Mother, Father and Child triple
MMR	Mild mental retardation
MPC	Mental Processing Composite standard score
MR	Mental retardation
mRPM	Modified Raven's Progressive Matrices
MSCA	McCarthy Scales of Children's Abilities
<i>N</i>	Sample size
<i>n</i>	subsample size
NHANES III	The third National Health and Nutrition Examination Survey
NHMRC	National Health and Medical Research council
NICU	Neonatal Intensive Care Unit
NMDA	N-methyl-D-aspartate
NONVB	Nonverbal standard score
OCS	Obstetrical Complication Scale
OR	odds ratio
Pb	Lead
PbB	Blood lead
PbD	Dentine lead
PbH	Lead in hair
PCS	Postnatal Complication Scale
PDI	Psychomotor Development Index
PIQ	Performance IQ
PO	Perceptual Organization
PPVT	Peabody Picture Vocabulary Test
PPVT-S	Peabody Picture Vocabulary Test-Spanish Version
PRDB	Parental Report of Predelinquent and Delinquent Behaviour
PRI	Perceptual Reasoning Index

PSI	Processing Speed Index
RBC	Red blood cells
RLE	Recent Life Events Questionnaire
RMSEA	Root Mean Square Error of Approximation
RPM	Raven's Progressive Matrices
RT	Reaction Time
SBIS	Stanford–Binet Intelligence Scale
SCAN	Screening Test for Auditory Processing Disorders
SD	Standard deviation
SE	Standard error
SEQ	Sequential Processing standard score
SES	Socio economic status
SICD	Sequenced Inventory of Communication Development
SIM	Simultaneous Processing standard Score
SOA	Stimulus onset asynchrony
SPM	Standard Progressive Matrices – Classic Version
SRD	Self-reported Delinquency scale
TAFE	Technical and Further Education
USA	United States of America
VC	Verbal Comprehension
VCI	Verbal Comprehension Index
VIQ	Verbal IQ
WAIS	Wechsler Adult Intelligence Scale
WAIS-R	Wechsler Adult Intelligence Scale- Revised
WAIS-S	Wechsler Adult Intelligence Scale- Spanish Version
WAIS-III	Wechsler Adult Intelligence Scale-Third Edition
WCST	Wisconsin Card Sorting Task

WHO	World Health Organization
WISC	Wechsler Intelligence Scale for Children
WISC-IV	Wechsler Intelligence Scale for Children- Fourth Edition
WISC-R	Wechsler Intelligence Scale for Children – Revised
WISC-S	Wechsler Intelligence Scale for Children – Spanish
WISC-RM	Wechsler Intelligence Scale for Children – Revised, version for Mexico
WJ-III	Woodcock Johnson-Third Edition Tests of Cognitive Abilities.
WMI	Working Memory Index
WPPSI	Wechsler Preschool and Primary Scale of Intelligence
WPPSI-R	Wechsler Preschool and Primary Scale of Intelligence-Revised
WRAT-R	The Wide Range Achievement Test - Revised

Abstract

This study explores the relationship between children's cognitive abilities and lead (Pb) exposure within the theoretical framework provided by the Cattell-Horn-Carroll (CHC) taxonomy of cognitive abilities. An abundance of research has centered upon the environmental neurotoxicant Pb and the outcomes of severe Pb poisoning (like brain damage and coma) are undisputed. Whilst people in industrialised societies have 500-to-1000 times more Pb in their bodies than their prehistoric ancestors, successful abatement programs have meant that Pb levels in humans are currently their lowest in 50 years. Paradoxically, questions have emerged about the effects of even these low levels of Pb exposure on children's cognitive abilities. Indeed, research (Lanphear, Hornung, Khoury, Yolton, Baghurst, Bellinger et al., 2005) has suggested that lower levels of Pb exposure may have a more deleterious impact on children's cognitive abilities than exposure at higher levels.

This study investigates the relationship between low-level Pb exposure (mean blood lead (PbB) concentration = 4.97 $\mu\text{g}/\text{dL}$, standard deviation (*SD*) = 3.52, range = 1.0 – 19.3) and child outcomes in two Australian communities (Port Pirie and Broken Hill) where Pb derived from ore bodies through mining and smelting remains a source of exposure. One hundred and six children (mean age = 7.96 years, *SD* = 0.59) were assessed using a battery measuring broad factors delineated in CHC theory by supplementing Wechsler IQ (Wechsler Intelligence Scale for Children-Fourth Edition; WISC-IV) scores with measures of CHC abilities (e.g., subtests from the Woodcock Johnson-III Tests of Cognitive Abilities). Information about parental cognitive functioning and a range of potential demographic, familial, psycho-social and environmental and pre- and post-natal variables was also collected.

In unadjusted analyses, moderate, inverse significant associations were identified between PbB levels and performance on the WISC-IV and CHC factor scores. The shape of the curve of the association between PbB levels and WISC-IV Full Scale IQ (FSIQ) and the *g* factor, respectively, was non-linear. In covariate adjusted analyses (controlling for maternal

IQ (Wechsler Adult Intelligence Scale-Third Edition), birth weight, Middle child Home Observation for Measurement of the Environment Inventory (MC HOME) scores, number of stressful life events, annual combined family income, smoking during pregnancy and duration of breast-feeding), consistent findings emerged that suggested that low-level Pb may detrimentally impact children's speed of information processing capabilities (across the three measurement approaches used in this study: WISC-IV Processing Speed Index, the Speed of Information Processing factor and Gs Invaders). When the PbB terms were added to models of WISC-IV Working Memory Index and the Woodcock Johnson-III Tests of Cognitive Abilities (WJ-III) Long-term storage and retrieval factor, these PbB variables contributed significantly to variance in children's memory performance above and beyond the variance already explained by variables considered to impact cognitive development. The variables that consistently explained the most variance in cognitive performance, aside from PbB level, were incidence and duration of breastfeeding and family income level. Higher PbB levels were significantly associated with lower paternal cognitive ability, parental education, combined family income and quality of the home environment, larger family size and later birth order.

This research supports the assertion that there is no safe level of paediatric Pb exposure and therefore contributes to the ongoing debate about whether the intervention level for childhood PbB levels should be reconsidered. In addition, this thesis discusses the confounding effects of socio-cultural and environmental factors that influence children's cognitive abilities.

Thesis Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university of tertiary institution to Rachel Earl and, to the best of my knowledge and belief, contains no material previously written or published by another person, except where due reference has been made in text.

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Rachel Earl

Signed:

Date: 19/8/2011

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