EXPOSURES AND HEALTH EFFECTS AMONG FIELD WORKERS USING THE ORGANOPHOSPHATE CHLORPYRIFOS

BY

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M Sc

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DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary educational institution.

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M.CATTANI DATE

ABSTRACT

Chlorpyrifos, an organophosphate pesticide moderately toxic to humans via inhalation and dermal absorption (LD_{50} oral, rat = 226 mg kg^{-1}, LD_{50} skin, rabbits = 1265 mg kg^{-1}), is widely used to eradicate termites in Australia. A series of 28 surveys totaling 32 separate assessments, or 10% of all professional users in Perth, Western Australia, comprised biological monitoring, exposure assessment techniques, a health symptoms and work practices questionnaire. Chlorpyrifos metabolite 3,5,6-trichloro-2-pyridinol and alkyl phosphates were extracted from urine, and serum cholinesterase (SChE) and erythrocyte acetylcholinesterase from blood. Chlorpyrifos was extracted from 24 patches removed from a supplied cotton overall, cotton gloves worn under protective gloves, 7 absorbent patches placed on the skin and an organic vapour collection tube. Surface wipes were collected in the workers vehicle and on the workers forehead. Chlorpyrifos was applied in either 0.5% (n=2) or 1% (n=26) concentration of active ingredient in water solution. Surveys took place at pre-construction sites (n=5) where pesticide was sprayed onto a prepared site, existing buildings with concrete foundations (n=17) where pesticide was injected under pressure around the perimeter of the building and existing buildings with suspended floors requiring the worker to spray under floor (n=6). Combined left and right glove deposition was 9 mg $hour^{-1}$ (SD = 18 $mg.hour^{-1}$). Mean deposition on overalls was 14 $mg.hour^{-1}$ (SD = 12 $mg.hour^{-1}$), on skin patches was 0.2 $\mu g.cm^{-1}.hour^{-1}$, on vehicle gear-stick was 3 µg (SD = 8 µg) and, on steering wheels' was 3 µg (SD = 3 µg). The mean protection

factor of overalls, a ratio of outer layer and inner levels, was 75 (SD = 411). Mean air concentration of chlorpyrifos during an application was 30 μg m^{-3}, and 17 μg m^{-3} 8 hour TWA (SD = 40 μg m^{-3} 8 hour TWA), and in one group of 17 workers correlated ($p<0.05$) with ambient air temperature (15 to 38 ^{o}C). Urinary metabolites and SChE activity were effective indicators of exposure. The health symptoms questionnaire did not highlight significant health effects. A discrepancy between operators' perception of risk and their actual exposure requires addressing, for example the measured high deposition rate to hands was ineffectively controlled, as 48% or workers wore inappropriate or no gloves and only 26% washed their hands after completing their tasks. All workers indicated in the questionnaire they would wash their hands after completing their tasks. The questionnaire also highlighted a high incidence of poor work practices, 58% spilt the concentrate at least once a week, 74% had recently spilt/splashed diluted chlorpyrifos in their eyes and 90% on their boots, and 52% believed they would benefit from more education concerning chlorpyrifos. Observations concluded that workers unnecessarily increased their exposure by poor work practice. Recommendations include modification to pesticide worker education, licencing and health surveillance systems; an improvement in the understanding of the benefits of a health and safety management systems for employers, and pesticide suppliers taking a stewardship role in the usage of their products.

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PUBLICATIONS

The following publications are directly related to the thesis, and are reproduced in Appendix 5:

Cattani, M. P., Pisaniello, D. L., Edwards, J. W. and Cena, K. (1998) Pesticide Exposure Monitoring. In *AIOH 98* Australian Institute of Occupational Hygienists, Canberra, Australia.

Cattani, M., Pisaniello, D., Edwards, J. and Cena, K. (2000) Comparative study of methods of dermal exposure assessment and control. In *IOHA 4th International Scientific Conference* (Ed Manuell, R. W.) International Occupational Hygiene Association, Cairns.

Cattani, M., Cena, K., Edwards, J. and Pisaniello, D. (2001) Pest control operators: risk perception and practice of pest control operators using chlorpyrifos *Journal of Occupational Health and Safety - Australia and New Zealand,* 17**,** 295-299.

Cattani, M., Cena, K., Edwards, J. and Pisaniello, D. (2001) Potential dermal and inhalation exposure to chlorpyrifos in Australian pesticide workers *Annals of Occupational Hygiene,* 45**,** 299-308.

ABBREVIATIONS & SYMBOLS

µg	microgram
AchE	Acetylcholinesterase
AS #	Australian Standard reference number #
BCA	Building Code of Australia
^{o}C	Degrees centigrade
CAS #	Chemical Abstract Service number
Cm	Centimetre
DDT	1,1'-(2,2,2-trichloroethylidene)bis[4-chlorobenzene]
DEP	Diethylphophate
DETP	Diethyl-thiophophate
EAChE	Erythrocyte Acetylcholinesterase
EPA	Environmental Protection Agency
h.p.	horse power
Hb	Haemoglobin
Hr	Hour
ILO	International Labour Organisation
Kg	Kilogram
KPa	Kilo Pascal's
L	Litre
LD_{50}	lethal dose required for 50% of individuals in a sample
Log	Logarithm
M	Metre
Mg	Milligram
Min	Minute
Ml	Millilitres
mm	Millimetre
MmHg	millimetres Mercury
N	number of subjects
NIOSH	US National Institute of Occupational Safety and Health
nmol	Nanomole
NOHSC	National Occupational Health and Safety Commission
NRA	National Registration Authority
NTE	Neurotoxic target esterase
OSHA	(US) Occupational Safety and Health Administration
OVS	Organic Vapour Sorbent
PchE	Plasma cholinesterase
PCO	Pest Control Operator/Operative, also known as pesticide applicator or pest controller.
Ppb	parts per billion
Ppm	parts per million
PVC	Polyvinyl chloride

SCE	Sister Chromatid Exchange
SD	standard deviation
TAFE	Tertiary and Further Education College
TCP	3,5,6-trichloro-2-pyridinol
US	United States (of America)
w/v	water to volume ratio

Note: The term “researcher” in this thesis refers to the candidate.

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FIGURES