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# Epidemiology of coronial deaths from pesticide ingestion in Australia

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ABSTRACT

Pesticides in Australia are tightly regulated but it is unknown how this may affect the distribution of misuse and self-harm across Australia, both spatially and within subgroups in the population. We performed an observational study to examine spatial differences in suicide/deliberate poisonings with pesticides in Australia. We examined Coronial inquest cases of self-harm by pesticide ingestion for the years 2001–2013 ($n = 209$). Coronial cases were older, more likely to be male, have lower SES status and live in outer regional areas as opposed to cities when compared to the general population. Case densities (cases/100,000 population) were lower in large capital cities and higher in agricultural areas: despite this half the cases occurred in major cities.



## 1. Introduction

In 2011 poisonings accounted for 23.5% of suicides in the Australian population, hangings 55.4%, firearms 6.0% and falls 4.5% (Australian Bureau of Statistics, 2013b). Self-poisoning by young adults in industrialized countries often involves poisoning via overdose of analgesics, tranquillizers, antidepressants (Gunnell et al., 1996). Medicine overdose has a case fatality rate (CFR) of around 0.5% (Gunnell and Eddleston, 2003), in contrast the CFR for pesticide ingestion is in the range 10–20% in the developing world (Eddleston, 2000).

Cases of non-fatal self-harm tend to have a higher incidence in females and rates peak in the 15–24 year age group. In attempts to explain these differences authors have postulated young people, especially females, are prone to engage in impulsive acts of self-harm, using methods readily available at the time of acute distress (i.e. prescription medicines) and that older males suiciding have greater access to more toxic chemicals, such as pesticides, and/or willingness to use more violent methods (firearms, falls or hanging) (Gunnell and Eddleston, 2003). In industrialized countries, suicide rates are three times higher in males than females, and rates are highest in persons aged over 70 years, although suicide remains the second leading cause of death globally among 15–29 year olds (Värnik, 2012).

Pesticides, defined here as agrochemicals used in farming/gardening and include herbicides, insecticides and rodenticides, have seen a rapid rise in use since the 1950s (MacFarlane et al., 2010). A range of chemical moieties are used in suicide including paraquat, organophosphates, glyphosate, carbamates, arsenic, anticoagulants and strychnine. Many are highly toxic to humans with high CFR among those who ingest them. Pesticide self-poisonings account for 30% of suicides globally, around 4% in the European Region to over 50% in the Western Pacific Region (Gunnell et al., 2007) and approximately 0.7% (141/21,000) in Australia in the years 2005–2013 (Australian Bureau of Statistics, 2015a). Access is consequently tightly regulated in Australia.

Farmers worldwide have been shown to have an elevated risk of suicide (Arnautovska et al., 2015) and this has been associated with several factors including geographic isolation, weather dependent livelihood and as such increased stress associated with natural disasters (e.g. flood, drought), poor access to mental health services, depopulation of rural areas and weakening of social ties, socioeconomic status (SES), and stoic and individualistic views of life (Alston, 2012). Differential suicide rates across metropolitan/rural/remote regions in Australia have been found with higher rates for males in rural and remote areas (Cheung et al., 2012). This complex milieu of risk factors suggests detailed data sets will be required to better understand the potential pathways to suicide,

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and discovery of any appropriate intervention points (World Health Organisation, 2014).

Restriction of access to the means of suicide has been shown to be a viable public health tool to reduce suicide, but evidence suggests it needs to be tailored to the population group being targeted (World Health Organisation, 2014). Areas with greater access to pesticides (and associated higher suicide rates due to higher CFR) may be areas where farming practices are common, but this may be confounded by access to appropriate mental health and medical services, types of farming (i.e. pesticides are not used in all types of farming), or increased access to firearms. Indeed, there is an unstudied assumption that access to pesticides differs between rural and city-based communities. The role of access has been found to be a potential avenue to decrease suicide rates (via lower CFRs) in other communities by limiting access via targeted banning of the most toxic pesticides (Eddleston et al., 2012), without compromising agricultural output (Manuweera et al., 2008).

While there is a presumably lower CFR in developed countries due to the choice/limited availability of less toxic poisons in suicide, little is known as to who, how and why self-harmers select less or more toxic substances, and whether there are areas in industrialized countries where access to pesticides is greater. We examine the demographics and risk factors for suicides involving pesticides and pesticide ingestion in Australia. We wish to describe the patterns of pesticide use in self-harm (parasuicide and suicide) in Australia to determine whether they present highlight any opportunities for prevention and/or public health planning.

## 2. Material and methods

Coronial inquiry (judicial inquiry to determine cause of death) mortality data was derived from the National Coronial Information System (NCIS), an internet-based data storage and retrieval system for Australian and New Zealand coronial cases. The NCIS contains case details of all 'reportable deaths' (these include but are not limited to transport fatalities, workplace deaths, drownings, suicides and poisonings). The NCIS was searched for closed cases from 1 January 2001 to 31 December 2013 for all Australian states. Cases where the NCIS field "object or substance producing injury" was coded as "other non-pharmaceutical chemical substance" and then "Pet (veterinary) product, herbicide or pesticide" were extracted. Results were manually reviewed to exclude veterinary products. To capture any cases coded incorrectly, the common chemical/trade names of pesticide were searched for in the free text "cause of death" field including "paraquat", "strychnine", "glyphosate", "methomyl", "organophosphate", "arsenic", "chlorpyrifos", "diazinon", "dimethoate", "mevinphos", "pesticide", and "herbicide".

Following extraction of cases, we coded the schedule of the pesticide involved in the death according to the Australian Poisons Standard (July 2015) (Therapeutic Goods Administration, 2015a). Where a pesticide was included in several schedules (e.g. chlorpyrifos is included in Schedule 5 and Schedule 6), the highest schedule for that substance was used. Cases were labelled with an intent completion according to each State Coroner's verdict (there are six State Coroners across Australia, and Coroners courts for the two self-governing territories) (National Coronial Information System, 2010). All cases irrespective of Coronial Court outcome were included in the study (i.e. those coded intentional self-harm, other specified intent, undetermined intent, unintentional and unlikely to be known, were included). This approach was undertaken due to issues in Coronial coding of suicides, such as bias found between judicial and medical definitions of self-harm, and known problems in the accuracy of Australian mortality statistics due to underreporting of suicides (De Leo, 2010). Cases under 12 years of age were removed in an attempt to avoid the bias of underreporting.

Data on intentional ingestions of pesticides were obtained from the New South Wales Poisons Information Centre (NSW PIC) database. The NSW PIC is Australia's largest poisons center, taking approximately 100,000 calls per year from healthcare professionals and members of the community. NSW PIC takes calls from Australian States NSW, Tasmania and the Australian Capital Territory (ACT) on a near full time basis, with after-hours calls taken for the whole nation on 7 of 14 days per fortnight as part of the national roster. Only calls originating from NSW, ACT or Tasmania were included in this study as these are the States where the data are the most complete. The database was searched for cases occurring from 1 January 2004–31 December 2013. Cases where the substance group category was coded as "Pesticide" were extracted. Strychnine cases were extracted separately, by searching for "Strychnine" in the substance description field. Only cases where the route was coded as "ingestion" and the exposure type was coded as "intentional" were included. Data obtained included date and time of case, hospital name, poison, amount ingested, patient age and sex. While a high proportion of ages were missing from the pesticide ingestion cases (61%), a high proportion had been classified into four age categories: child 0–14 years, adolescent 15–19, adult 20–74, and elderly ≥75 years (12.6% missing). Collection of data was hampered due to call center nature of the PIC, with gender having 4.7% missing. 97.7% of ingestion cases were calls were from hospitals, reflecting the severity of symptoms on ingestion of this class of chemicals. A further 7 of 21 non-hospital related calls supplied their postcodes meaning 98.4% of cases could be geo-located via postcodes.

We used Google Maps API with the statistical package R (R Core Team, 2015) to derive geolocation of Coronial poisoning patients using their domicile street address (apart from West Australia residents where postcode alone was used). For pesticide ingestion patients, we used the name of the hospital from which the call to NSW Poisons Information Centre was made to locate patients. We then entered geolocation data into ArcGIS Desktop 10.2 (ESRI, Redlands, USA) in order to link to a range of publicly available information from the Australian Bureau of Statistics (ABS). We generated data to achieve geolocation of Australian hospitals ($n = 403$) and each State's General Post Office (GPO, the primary postal building in the capital city, used as a proxy for center of capital city of each state), and distances to cases calculated. Euclidean distance to hospital and GPO was measured with ArcGIS. We geo-located patients to ABS Statistical Area 1 (SA1), the smallest area of output for the Census of Population of Housing conducted by the ABS in 2011. Each SA1 Area contains approximately 400 people (range 200–800) and there are 54,805 SA1 areas in Australia. SES was determined using the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), one component of the Socio-Economic Indexes for Areas (SEIFA). The IRSAD is standardized to have a mean of 1000 and a standard deviation of 100 across census collection districts (Australian Bureau of Statistics, 2015b).

Patients were also assigned an Accessibility/Remoteness Index of Australia (ARIA) score based on the location of their domicile (Coronial cases) or hospital attended (pesticide ingestion cases). ARIA scores are based on road distance to the nearest service centers. The ABS defines five classes of remoteness, based on the ARIA score: major cities, inner regional, outer regional, remote and very remote. To examine differences in case density homogeneity across Australia cases were geo-located to SA4 (ABS Statistical Level 4, 2011) which contains between 100,000 and 300,000 people and the number of cases divided by the population of each SA4 in 2011.

To calculate cases per million per year to compare Coronial and ingestion cases we divided the number of cases by the number of years to give $n$/million/year. Population estimates for the denominators were derived from data from the ABS website by combining 2011 Census data with ARIA boundaries in ArcGIS. Age-adjusted mortality rates were calculated for each State and Territory using