enHealth Position Statement: Clandestine Drug Laboratories and Public Health Risks

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Position Statement Summary

In many western countries especially the United States (US) and Australia there have been increasing numbers of clandestine laboratories (clan labs) being found.

Although the bulk of chemicals and equipment used are normally removed by the police, contaminant residues remain on many surfaces and areas at the site. As most clan labs are discovered in residential buildings, these residues also place existing and future occupants at potential health risk.

Although there is comprehensive national guidance in the form of the *Clandestine Drug Laboratory Remediation Guidelines – 2011* (Australian Government, 2011), they have only been implemented to a limited extent and require better local risk information and communication to make them effective and workable.

National illicit drug incidence data (ACC, 2012) indicates that Queensland and Western Australia have disproportionately higher numbers of detected clan labs, especially on a population basis. Although methylamphetamine labs are the most common by far, there tends to be east to west differences in the main production methods.

The major sources of public risk from clan labs can be ascribed to methylamphetamine exposure particularly (as a persistent production residue) and also from toxic or flammable gases when the labs are actively operating. Methylamphetamine and associated contaminants can spread widely at a site.

Children, possibly numbering hundreds per year, are likely to be the most at risk population exposed to contaminants associated with “discovered” clan labs. The number of children at risk in undiscovered labs may be ten fold higher.

Based on contaminant level studies for similar clan labs in the US it is likely that a reasonable proportion of exposed children and adults will suffer at least minor behavioural, psychological or physiological health effects. The frequency and severity will increase with the nature, level and duration of such exposure.

Purpose

The purpose of this document is to highlight the potential public health risks associated with chemical contamination at clandestine laboratories (clan labs).

As clan lab assessment and management systems vary across Australia, for guidance in these regards please contact your State or Territory regulator as listed under Health Agency Information at the end of this document.

Background

Tighter restrictions on the transnational illicit drug trade have prompted growth in local clan lab manufacture operations particularly in Western countries. In this

document, clan lab manufacture refers to the production of illicit drugs or precursors within an improvised laboratory environment (Newell, 2008). It can include extraction, chemical reaction and/or tablet making operations.

The growth in clan labs in Australia is shown in Table 1 from the Australian Crime Commission (ACC, 2013), peaking at 809 detections in 2011-2012. However, many thousands more clan labs may never be found and continue to operate until eventually abandoned.

Table 1: Number of clan lab detections, by State and Territory, 2002–03 to 2011–12

Year	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Total
2002–03	47	19	171	34	36	2	3	2	314
2003–04	61	20	189	48	33	1	6	0	358
2004–05	45	31	209	25	44	3	21	3	381
2005–06	55	47	161	50	58	5	12	2	390
2006–07	49	72	132	51	37	9	1	5	356
2007–08	51	76	121	69	30	2	1	6	356
2008–09	67	84	148	65	78	0	7	0	449
2009–10	82	113	297	71	118	1	12	0	694
2010–11	87	63	293	75	171	11	2	1	703
2011–12	90	99	379	58	160	15	7	1	809

Clan labs are subject to a range of legislation and strategies designed to take action against the misuse of drugs, and these have also identified the need to minimise risks to the public, especially children, who are incidentally associated with such labs. (AIC, 2007)

The police and forensic agencies typically remove clan lab bulk chemicals, containers and equipment as part of their investigation and management of illicit drug activities. Still, a range of chemical residues may remain on-site posing a risk to occupants and others due to these improvised activities by usually untrained offenders who care little about safe management of dangerous chemicals.

As the majority of clan labs are in residences (non-workplace settings)(ACC, 2013), any resulting risks are usually subject to State or Territory public health legislation, in particular the habitability of a residence. If the clan lab is in a workplace or affects the environment, then other setting-specific legislation will apply.

Some countries have recognised real and potential risks of such contamination and have published guidance material to help manage them. The US has done much in this area, having had a large problem for decades. New Zealand (NZ) (Ministry of Health, 2010) and Australia (see below) have produced guidance in the last three

years, including investigation and management procedures in support of the key stakeholder groups.

In Australia the Australian Government Department of the Attorney-General published the *Clandestine Drug Laboratory Remediation Guidelines* (Guidelines)) in 2011 (Australian Government, 2011). This comprehensive document covers the assessment, remediation, validation and management of detected clan labs.

These Guidelines also recognise that since there is variation across Australian jurisdictions in relation to illicit drug manufacturing processes, local practices and legal systems, the guidance would need to be customised by each authority into a form suitable for local application. Queensland, Victoria and Western Australia have already released such guidance documents (see relevant web addresses in the Health Agency Information section).

To help further drive and focus the management process, enHealth has commissioned this paper to identify the nature and degree of potential public health risks associated with clan labs.

The paper does this by reviewing for Australian circumstances (with reference to overseas' experience) the likely character of clan contamination, the human exposure scenarios and the potential health effects associated with contaminant exposure, to try to arrive at an estimation of the real likely health effects.

Overview of Manufacture and Contamination

Clan Labs and Processes

There are a wide range of chemicals and therefore contaminants associated with clan labs, depending on the illicit drug involved, the production process, and the improvised materials used. Over 100 different recipes may be used to manufacture common illegal drugs, resulting in an even greater number of possible chemical contaminants (Wright, 2009). Contaminants may include precursor chemicals, process support chemicals, illicit drug products or by-products, and chemical production wastes.

The main illicit drugs made in Australia include amphetamine-type stimulants (ATS), 3,4-methylenedioxymethylamphetamine (MDMA or ecstasy) and pseudoephedrine (PSE)/ ephedrine extraction (for ATS purposes). ATS production primarily consists of methylamphetamine, i.e. meth, speed or ice, but also covers other drugs such as amphetamine, phenethylamines and MDMA (unless specifically excluded) (ACC, 2013).

Table 2 provides a jurisdictional summary of the number of clan labs detected in Australia for 2011-2012 on the basis of the production method used (ACC, 2013). It also incorporates, in terms of Totals, data from 2010-2011 (ACC, 2012).

Table 2– Detected Clan Labs by Drug, Production Type, Jurisdiction 2011 -12[#]

State/ Territory	ATS (ex MDMA)					MDMA	PSE/ ephedrine extraction	Other/ unknown	Total *(2010/11)*
	Total	*Hypo* phos*	*Red* phos*	*Nazi/* Birch*	*P2P**				
QLD	241	*(201)*	*(38)*	*(0)*	*(2)*	0	3	137	381 *(296)*
WA	156	*(0)*	*(6)*	*(149)*	*(0)*	0	0	7	163 *(171)*
NSW	75	*(62)*	*(0)*	*(2)*	*(2)*	2	0	13	90 *(88)*
VIC	58	*(39)*	*(7)*	*(2)*	*(9)*	0	7	33	98 *(63)*
SA	49	*(39)*	*(6)*	*(0)*	*(2)*	1	1	10	61 *(75)*
TAS	11	*(6)*	*(0)*	*(4)*	*(1)*	0	1	15	27 *(11)*
NT	7	*(7)*	*(0)*	*(0)*	*(0)*	1	2	1	11 *(2)*
ACT	0	*(0)*	*(0)*	*(0)*	*(0)*	0	1	0	1 (1)
Total	597	*(354)*	*(57)*	*(157)*	*(16)*	2	17	216	832^ (*707)*
Total 2010/11	556	*(282)*	*(36)*	*(183)*	*(17)*	16	34	101	(707^)

[#] Adapted from ACC, 2013.
* Breakdown of ATS methods used to produce methylamphetamine, specifically using hypophosphorous, red phosphorus, Nazi/Birch and phenyl-2-propanone (P2P) related reactions.
^ Number slightly inflated due to multiple methods used in some laboratories.

Analysis of the ACC reports plus other information provides the following relevant additional insights:

- There were significant changes between the clan lab data presented in 2011-2012 compared to 2010-2011. This included marked increases in the clan labs detected in QLD, VIC, TAS and NT, and also in the use of hypophosphorous and/or red phosphorus production methods

- The higher rate of detections in QLD (phosphorus methods) and WA (Nazi/Birch method) than in NSW and VIC is even larger on a population basis

- Detection trends with the less common illicit drugs or drug processes are hard to determine because there can be considerable annual and jurisdictional variation in these numbers

- The laboratory size distribution was as follows: addict-based (smallest size, mainly for personal or close group use) 79%; other small scale 12.8%; medium size 5.5%; and industrial scale 2.7%. QLD and WA clan labs were 90% addict-based

- Large scale illicit drug production is more commonly associated with commercial/industrial sites and primarily presents an occupational risk for incidental exposed groups. In NSW about 50% of laboratories were categorised as medium to large scale

- Most clan labs are either in or adjacent to domestic dwellings (70.6%). Other sites include vehicles (8.5%) (for storage/transport), public places (7.8%), rural (3.1%), commercial/industrial buildings (2.8%), and other (7.2%)

- A significant proportion of domestic dwellings involved may be part of public housing programs. See Howell (2013) below

- Nearly half the clan labs found had actual operations associated with them at the site, the balance being primarily storage sites, such as vehicles

- In domestic dwellings, wet areas (kitchens, laundries and/or bathrooms) are commonly used for manufacturing/cooking as they have hard surface work areas, a water and electricity supply, and sinks for disposal purposes

- About 1 in 10 clan labs are thought to be detected in Australia, while others continue to operate until they are eventually abandoned or relocated (Newell, 2008). However, a report on clan labs in the US in 1992 indicated that this ratio was 1 in 4 clan labs (Skeers, 1992)

Information available from the Western Australian Department of Health clan lab notification and management database system is also useful on a jurisdiction specific basis (Howell, 2013; Western Australian Department of Health, 2012). In the 12 month period from August 2012: 99 clan labs detections were reported; 60% of all clan labs were in residences (16% Government owned) and about 35% were associated with bushland or vacant land; 40% of all residential clan labs had children at the premises (average of two); the Nazi/Birch production method still dominated though the more recent appearance (2011-2012) of phosphorus methods continued; and about 10% of sites detected were related to fires or explosions.

Therefore although jurisdictions vary, the dominant type of clan lab in Australia consists of small scale methylamphetamine production in a residential setting using the hypophosphorous or Nazi/Birch methods.

NZ data reveals that in 2008: 62% of clan labs were methylamphetamine-related (where production method was known); the phosphorus methods were most common followed by the Nazi/Birch; and residential dwellings were most frequently used, in particular rental properties. (Fisher *et al*, 2011; Ministry of Health 2010) This indicates that clan lab similarities exist between New Zealand and Australia, particularly for methylamphetamine production processes and circumstances associated with the eastern Australian States.

Chemicals and Contamination Characteristics

Many of the multiple chemicals that can be used to make illicit drugs are toxic, flammable and/or corrosive. Wright (2009) has undertaken an assessment of illicit drug production in Australia, which provides part of the basis for the Guidelines. Wright (2009) has identified the main contaminants of concern as listed in Table 3, taking account of practical issues and toxicological factors. pH is included here to cover common corrosive materials such as sodium hydroxide and hydrochloric acid (also an airborne contaminant as hydrogen chloride).

Table 3 - Clan Lab Key Chemical Contaminants (Wright, 2009)

Methylamphetamine	Boron and compounds
MDMA	Mercury (inorganic)
Ephedrine and pseudoephedrine	Lithium
Ammonia	Benzaldehyde
Iodine	Phosphine
Bromide	Safrole and isosafrole
Phosphorous (acids) & red phosphorus	Chloroform
N-Methylformamide	Dichloromethane
Methylamine	pH
Nitroethane	
Petroleum Hydrocarbons Benzene, Toluene. Ethylbenzene, Total Xylenes, Napthalene, TPH# fractions	

TPH= total petroleum hydrocarbon

Also NZ, which has similar clan lab-related issues to Australia's eastern States, has identified as key contaminants methylamphetamine, iodine, mercury (inorganic), phosphine, pH, benzene, toluene, xylenes, hydrogen chloride and lead. (Ministry of Health, 2010) The shortness of the list is based on the rationale that if these chemicals are remediated then other potential contaminants will also be removed.

The most important contaminant in terms of public health risk and management is usually methylamphetamine. It is the most commonly produced illicit drug in Australia, invariably is a persistent contaminant in associated laboratories (Martyny, 2008), has the lowest derived clean-up threshold level in the Guidelines, and is also the main focus of clan lab remediation management efforts in the US and NZ.

The following points are important when determining the nature in particular of methylamphetamine contamination at an Australian clan lab site:

- Contamination usually results from overheating chemical reactions, poorly managed extractions, and spills or dumping of chemicals (Newell, 2011)

- The level of contamination depends on the processes and methods involved, scale and operational status of the lab, and duration and frequency of operation

- For a given amount of drug produced there may be three to thirty times that quantity of chemical waste generated (Newell, 2013). For methylamphetamine the US Drug Enforcement Agency has estimated this to be five to seven times the amount of product (Horne, 1997)

- Contamination can be transient or residual. Gases such as ammonia and phosphine are transient and only likely to be present in the air during or shortly after active drug production (Ministry of Health, 2010). Vapours from liquids can be retained in and be re-released to air from soft furnishings or surfaces for some time after clan lab operations cease (Australian Government, 2011)

- Residues are more persistent and are usually in the form of surface deposits (salts), or liquids (methylamphetamine base oil or reagent chemicals) that have absorbed into porous surfaces or materials such as plaster board

- Martyny (2007) identified the main chemicals of concern during the real-time operation of common types of methylamphetamine labs to be airborne, specifically phosphine, hydrogen chloride, ammonia and methylamphetamine aerosol. Iodine may also be an issue for the red phosphorus production method (less common in Australia except in QLD)

- Methylamphetamine (including its salt) is usually the main contaminant after its production has ceased and can persist as a surface residue for months or years (Martyny, 2008). It is generated as a reaction aerosol and through the "salting out" step (hydrogen chloride gas bubbling) commonly employed in the phosphorus and Nazi/Birch processes (Martyny, 2007)

- Any gases or aerosols released are often likely to be initially contained in the building at high levels because the operators may have disabled ventilation systems to avoid detection by escaped fugitive odours (Wright, 2011)

- Methylamphetamine is likely to contaminate any person in its vicinity. Even after a single small "cook", surfaces will be contaminated in both nearby and more distant areas, depending on the production method (Martyny, 2007). Contamination of adjacent ventilation systems as well as plumbing systems may also occur

- For methylamphetamine manufacture, the phosphorus reduction methods (hypophoshorous and red phosphorus) are substantially more contaminating than the Nazi/Birch method both to the air and on surfaces (Salocks, 2009a). However, some of this contamination may be as methylamphetamine base which can dissipate by volatilisation

- Methylamphetamine contamination can also occur due to smoking ice, the crystal form of the drug. Although this is not as "dirty" as production-related contamination, it can add to the contaminant loading, especially over time, and affect other areas in the building (Martyny *et al*, 2004a)

- For other potential contaminants Martyny *et al*, (2004b) determined that metals were only present at very low levels and hydrocarbons were impractical to measure due to potential interference from household chemicals. Also in most cases methylamphetamine was a better indication of contamination risk than its starting materials, pseudoephedrine and ephedrine (Martyny *et al*, 2004b)

- For the less common MDMA clan labs, the contaminants of main concern according to Wright (2009) include formamides and safrole/isosafrole during operations and afterwards residues of MDMA salts and safrole/isosafrole. For some processes liquid waste containing mercuric chloride can also present a hazard depending on where it ends up

- Environmental contamination of water and soil can occur from the dumping/burial of waste or through use of outdoor areas for production. Sodium hydroxide waste is one such hazard and since it is usually present as a solid it will tend to remain on the soil surface, though possibly infiltrating with rain water into soil over time

- Fires and explosions within clan labs can result in dwelling and environmental contamination, and are commonly how many clan lab activities are initially discovered (Martyny, 2007; Wright 2011)

Consequently there will always be some contamination associated with a clan lab operation and in most cases it will persist in buildings as methylamphetamine residue. The remainder of this document will therefore focus on methylamphetamine as a source of public health risk. Other contamination concerns will also be addressed where appropriate.

Contaminant Levels

There is very little data available about contaminant levels in Australian clan labs. This may change as assessment and remediation activity increases nationally.

The most useful information is the work of Martyny *et al* (2004-2008) in Colorado who have undertaken contaminant measurements for both real and simulated methylamphetamine clan labs. This may indicate what contaminant levels may be possible in Australian clan labs since there are similarities to the main methylamphetamine methods used in the US, hypophosphorous, Nazi/Birch and red phosphorus (Martyny *et al*, 2005b, Queensland Department of Health, 2012).

For 89 samples from 14 suspected methylamphetamine labs primarily in residences, Martyny *et al* (2004b) found the overall mean methylamphetamine surface sample concentration to be 511 ug/100cm^2 (range of means 3 - 3057 ug/100cm^2) and sample concentration range of ND (not detected) – 16000 ug/100cm^2. The median methylamphetamine concentration was 28 ug/100cm^2. ND results were quite rare. This sampling was not systematic, extensive or intended for risk assessment purposes. If the emphasis had been on proximate horizontal surfaces the levels found may have been higher.

The production methods were not outlined but many seemed to involve the red phosphorus method that can have methylamphetamine contamination characteristics similar to the hypophosphorous process common in Australian eastern States.

Martyny *et al* (2005a, 2005b) also conducted simulated methylamphetamine cooks that resulted in a mean methylamphetamine contaminant level of 54 ug/100cm^2 with a range of 0.1 – 860 ug/100cm^2 for phosphorus-related methods (5 cooks) and 9 ug/100cm^2 and 0.1 – 160 ug/100cm^2, respectively, for the Nazi/Birch process (3 cooks). The higher levels of contamination associated with the phosphorus methods in comparison with the Nazi/Birch method were particularly exaggerated as distance increased from the production area. Despite the range of variables involved, there is some consistency between these results and those from actual clan labs (for phosphorus methods) if one assumes a one year operation with a weekly production cycle and limited loss through cleaning or disturbance.

During these cooks Martyny *et al* (2004b) also conducted air contamination measurements. The maximum levels of contaminants of most concern were:

methylamphetamine 5.1 mg/m^3, phosphine 4.1 mg/m^3, hydrogen chloride 233 mg/m^3 and ammonia 686 mg/m^3.

As clan lab operators are also likely to be drug users, it is worth noting the study by Martyny *et al* (2004a) of methylamphetamine contamination due to smoking the drug. The research found that after two "regular" smokes (simulated pipe, 100 mg dose, assumed 90% body absorption), the mean surface contamination of adjacent areas can be 0.07 ug/100cm^2. Even with multiple smokes these levels are likely to remain much lower than for "cooks". Although historically injection may have been more common in Australia than smoking, at least for hard core methylamphetamine users (McKetin *et al,* 2012), this trend may be changing. This is indicated by recent record seizures of ice (usually smoked), for instance 585 kg in Sydney in February 2013, accompanied by a dramatic reduction in heroin seizures.

From the above, the results from real detected labs are probably best to give an indication of surface contamination levels, and the simulated cooks can indicate possible airborne contamination in the absence of real data. The levels found may suggest what is possible in Australia in comparable situations, noting that there will be some difference in the methods used and that smoking may be more common around labs in the US and so increasing their surface contamination levels in some areas at least to a minor degree.

Exposure Considerations

Contamination becomes a potential health risk when humans are exposed to hazardous contaminants. The nature and extent of exposure will depend on a number of different factors as outlined below, including clan lab factors (status and location) as well as exposed groups involved.

Clan Lab Factors

Clan labs are likely to cause the highest levels of contaminant exposure to occupants when the cooking process is in operation, although this may be of a short duration compared to their exposure to residues remaining after operations have ceased.

Clan labs that remain undetected continue to have this exposure profile. Once clan labs are detected the subsequent exposures will relate to residual surface contamination until remediation occurs.

The greater the clan lab scale, lifetime and frequency of operation, then the larger the potential for contamination and exposure. While such factors will vary, addiction based methylamphetamine clan labs (most common in Australia) normally produce no more than 3gm of drug per production run. Based on this figure and common drug use patterns (McKetin *et al* 2012), many clan labs might operate on a weekly or fortnightly frequency.

Over time contamination associated with any clan lab will decrease through dispersion, dilution and degradation, if not regenerated. However if the initial contamination was high, contaminant levels of concern may potentially remain for

years. In the case of the Holt family in the USA, their range of health effects was the result of clan lab residues that persisted for more than five years (New York Times, 2009).

Contamination levels and exposure potential will be greatest where the clan lab operations specifically took place. This may be particularly important if it happens to coincide with a much used communal area. As indicated previously, wet areas are most common locations, especially kitchens which as a place of food preparation can result in even further potential for exposure. Contamination can also often spread into adjacent areas.

Exposure from illicit drug processes conducted or materials spilt or disposed of in residential yards and public areas is very difficult to estimate because of the great variation in where, what and how this has occurred, as well as in the possible activity patterns of potentially exposed groups. The WA clan lab data previously discussed indicated that in recent times about 30% of sites were bush or vacant land, and also 10% of sites were residential yards (Howell, 2013). So for WA during that period potential for environmental contamination frequently accompanied clan lab finds.

Exposure in such environmental situations would most likely be significant in the case of residential yards due to greater opportunity there for closer and prolonged personal contact. This exposure may more likely occur if visual indicators are not good or some bulk chemicals remain due to practical problems for their removal by police, for instance if mixed in with soil. Even so exposure is likely to be less in most cases than for contamination in residences, where people spend much of their time and in a confined space.

Another environmental exposure situation could be if the contaminant ends up in ground or surface water intended for human use. Again this hard to predict or estimate.

Exposed Groups

Clan lab operators or “cooks” are typically exposed to contamination, during and as a result of any manufacturing (Martyny, 2007). However the methylamphetamine exposure may be low compared to when the drug is consumed by them.

A major population of concern are the other (non-cook) occupants of a clan lab dwelling. These people, usually family members and including children and infants, may be less directly exposed to contaminants released during production but are exposed to some residual contamination. These occupants, especially the children, may not be exposed by their own volition.

US, Australian and NZ experiences indicate that about one third of methylamphetamine lab detections have children associated with them and in many cases there could be several children involved (Martyny, 2007; Ministry of Health, 2010; AAP, 2011; Howell, 2013). Based on this and the clan lab occurrence data presented earlier, each year there may be an several hundred additional children found to be associated with detected clan labs in Australia and possibly several thousand children involved with undetected labs on an ongoing if variable basis.

Children considered to be exposed the most are those in the six month to two year age group, due to their high contact time with the floor and level of hand/object-to-mouth (pica) behaviour (Salocks, 2009b).Toddlers are also likely to remain in the dwelling on a more continuous basis. This age group may represent about 10% of the children present, extrapolating from Australian Bureau of Statistics data (ABS, 2012). Also children in clan labs are exposed to significant risk from abuse, neglect and other adverse influences which may exacerbate any effects from contaminant exposure (Bratcher *et al*, 2007).

The number of potentially exposed adults will be even greater than that for children. Western Australian data for 2012-2013 indicates an average of nearly three adults for each detected clan lab in a residence (Howell, 2013). If people move into a dwelling after clan lab operations cease they may be unaware of these previous illicit operations. These individuals may have family members who are pregnant, elderly, frail or have compromised health, placing them at increased risk. Given that existing or new occupants may be residents at such properties for at least a few years and that contamination will diminish with time, it is likely that any subsequent occupants will only be exposed to a lower and possibly inconsequential level of contamination than their predecessors.

Other groups that may be exposed to contamination are visitors to the clan lab site, and people involved in regulatory or remediation activities of detected labs. Visitors, such as friends, relatives, tradesmen and real-estate agents, are only likely to have transient incidental exposure. However, some higher exposure scenarios do exist such as tradesmen working in a contaminated confined area such as a roof space.

Although regulatory officers may be closely exposed to the contamination for a short time, they would be expected to take precautionary measures and wear appropriate personal protective equipment. Such exposure would be occupational rather than public health related.

Any exposure to neighbours is likely to be very low except possibly from clan lab fires, explosions or occasional fugitive gases during operations, backyard chemical dumping, or in high density housing situations.

Exposure Routes

Common exposure routes of inhalation, skin contact and ingestion to clan lab contamination vary in importance with agent, risk population and situations, such as building location.

Inhalation exposure can occur as a result of gas and aerosol release during and shortly after production. Methylamphetamine can also be regenerated as an aerosol hazard if its residues are disturbed the following day or beyond, particularly as a salt. The methylamphetamine aerosol has been found to be less than 0.1 um in mass median aerodynamic diameter and therefore it is able to penetrate deep into the lungs, from where it can be absorbed into the bloodstream (Martyny *et al*, 2005a).

The main exposure route of residue materials is through dermal contact (i.e. absorption through the skin) and to some extent contaminated hand/object-to-mouth behaviour especially for children (Salocks, 2009b).

Exposure Studies

Studies have shown that occupants of a clan lab site will have contamination of their body and clothing as a result of its operation, the level of which will depend on the particular circumstances. This is based on clothing and skin swabs, hair analysis and also urine tests, including those from children (Wright, 2011). For simulated methylamphetamine"cooks', Martyny *et al* (2008) found that 68% of people who had entered the property were contaminated and of these the mean level of methylamphetamine surface contamination was 11.2 ug/100 cm^2, with a range of 0.04 to 580 ug/100 cm^2. Visitors to non-operating clan labs had the lowest contamination levels and production participants the highest

Therefore given the numbers of detected and possible undetected clan labs in Australia, and their propensity for contamination, it is likely that many people have been exposed to methylamphetamine and/or other hazardous chemicals to some extent over their lifetimes.

Potential Health Effects and Toxicity

There is now a reasonable body of information on the health effects of methylamphetamine in humans due to the fact that it has been a drug of abuse for many years and also used therapeutically for weight loss programs and to treat Attention Deficit/Hyperactivity Disorder (ADHD) in children. However these do not fully cater for possible clan lab exposure scenarios such as longer term low level exposure to all subgroups of the relevant population. Health effects information on many of the other contaminants of concern derives from incidental exposures or animal studies.

Generally children are considered more susceptible than adults to adverse effects from chemical toxicants due to their developing physiology, especially their central nervous systems. These developmental risk factors also apply in regard to pregnant women given that methylamphetamine will cross the placental barrier and adversely impact on the developing foetus (Ganapathy *et al*, 1999).

The most detailed and relevant Australian publication about the health effects and toxicity of clan lab contaminants is that of Wright (2009) which focuses on the contaminants listed in Table 3. Another very useful reference is the New Zealand Ministry of Health's 2010 Guidelines. Wright (2011) identifies three temporal classes of health effects from clan lab operations, being immediate, acute and chronic.

Immediate Exposure Effects

Immediate exposure health effects can result from sudden releases of toxic material, explosions or fire which in some instances may pose an immediate threat to life or long term disability particularly from the respiratory effects of corrosive or poisonous

gases or from large scale tissue damage. Up to 20% of clan labs in residences both in Australia and the US may be identified as a result of an explosion or fire (Roper, 2007).

Acute Exposure Effects

Acute exposure effects may result from short-term (for instance hours or days) high level exposure to toxic chemicals usually generated coincidentally due to poor safety practices during the production process. This is also likely to involve gases or aerosols and depending on the chemical, could produce a range of effects such as eye irritation and respiratory effects. In Australia the main compounds of concern are methylamphetamine, phosphine, ammonia and hydrogen chloride as mentioned above.

Methylamphetamine aerosols can potentially produce physiological and psychological effects, especially for naïve exposure groups. Effects may include skin, eye and respiratory irritation as well as dizziness, headache and insomnia (Ministry of Health, 2010).

Martyny (2007) states that phosphine may cause severe pulmonary irritation resulting in pulmonary oedema and death. At lower levels it may cause nausea, vomiting, headache and chest tightness (Ministry of Health, 2010).

Ammonia and hydrogen chloride are both corrosive gases which will affect the eyes and respiratory track with damage increasing with concentration, possibly resulting in pulmonary oedema and death.

Chronic Exposure Effects

Chronic exposure effects may be due to longer term exposure (weeks, months or years) to lower contaminant levels.

Methylamphetamine, the most likely persistent residue in Australia, is a powerful stimulant which can produce central nervous system effects (Ministry of Health, 2010). Wright (2009) reports that longer term exposure to methylamphetamine may cause severe skin conditions, insomnia, irritability, poor concentration, hyperactivity, personality changes, weight loss, teeth grinding and tooth loss, ulcers of the lips and tongue, physical and psychological dependence, fear, compulsive behaviour, delirium, disorientation, hallucinations, or a psychotic schizophrenic-like condition with a possibility of self-injury.

Prolonged exposure to methylamphetamine also causes cardiovascular effects including increased heart rate, blood pressure and at higher or sustained exposure, chest pain, hypertension and the risk of stroke (Ministry of Health, 2010). Kidney and renal effects may also be possible (Wright, 2011).

For external disposal areas associated with clan labs, e.g. house yards, human exposure (acute or chronic) may also result from the dumped contaminants, either by direct contact in situ or through local water supplies if they become affected. Sodium hydroxide is such a chemical of health concern, as it is highly corrosive and can be

hazardous by skin contact or incidental ingestion. Additionally, the dumping of mixed sodium hydroxide and ammonium sulphate wastes pose a risk from ammonia evolution if they become wet.

It s also probable that multiple chemical exposures may occur which may modify in uncertain ways the likely significant effects of dangerous gas and/or methylamphetamine exposure.

Level of Health Risk

Although it is widely agreed that clan lab contamination represents a public health risk that needs to be managed there is little information on the health effects and level of risk. This may be due to the complexity of the issue as well as the legal, ethical and practical considerations.

It is also worth noting that even where the exposed population does present with physiological or psychological conditions, these may be the result of some other cause and cannot be readily ascribed specifically to clan lab-related exposures especially for low contaminant levels.

Health Evidence

In the US, New Zealand and Australia, it has been reported that many people, especially cooks, have been killed or severely injured as a result of clan lab explosions (Caldicott, 2005; Martyny 2007; Ministry of Health, 2010).

Acute effects during clan lab operation are not well documented probably due to the unwillingness of affected people to seek medical aid or reveal the cause. US hospital data shows frequent cases of chemical burns, particularly among operators (Wright, 2011). Nearly a quarter of all clan lab detections were associated with human injuries, again often associated with chemical as well as thermal burns Simulated cooks have shown ammonia, hydrogen chloride and phosphine air levels up to three times the occupational Immediately Dangerous to Life or Health Concentration (NIOSH, 1995). Also some deaths may be the result of exposure to phosphine gas in clan labs (Martyny, 2007).

Data from the Environmental Protection Information Centre National Clandestine Laboratory System database indicates that 700 children out of 2028 found at clan labs in the US in 2001 had tested positive for toxic levels of chemicals (Caldicott, 2005).

Some useful evidence of potential acute risks comes from clan lab exposures, surveys and data for clan lab first responders, which indicates that affected individuals suffer from illnesses such as irritant and mild respiratory effects and headaches (Thrasher *et al*, 2009; Wright, 2011). However, first responders would be exposed to lower levels than the operators and many of the occupants due to the responders' less direct exposures and likely use of safe practices.

For longer term exposures, there are anecdotal reports of increased asthma, pulmonary fibrosis, and upper respiratory complaints in children at methylamphetamine clan labs but no documented health statistics are available (Martyny, 2008). There have been reports of people, including children, exposed to/living in un-remediated labs with throat irritations, nausea, respiratory difficulties and headaches (Burgess 1997, New York times, 2009).

Wright (2011) has also cited reports of children being injured when inadvertently exposed to dumped clan lab waste material.

Non-Effect Levels

In the absence of data as to what level of clan lab contamination will produce a health effect, authorities in the US, Australia and NZ have developed clan lab contamination criteria for a range of chemicals, below which a health effect is unlikely.

Most of this work has been done on methylamphetamine, although Wright (2009) has also derived these criteria, termed Health Investigation Levels (HILs) for the chemicals listed in Table 3. HILs have also been derived for a range of exposure routes and different clan lab situations, e.g. occupational and environmental settings.

Only the data on methylamphetamine contamination in conjunction with its surface HIL allows for some risk estimates to be made, primarily for longer term exposure. In this way methylamphetamine is used as a surrogate in managing risks of other clan lab contaminants because of its low threshold for effects and its predominance as a clan lab contaminant (Ministry of Health, 2010; Queensland Department of Health, 2012; Western Australian Department of Health, 2012).

In the US the methylamphetamine clean up criteria varies amongst States from 0.05 to 1.5 µg/100cm^2 for surface contamination, with 0.1 ug/100cm^2 being the most common (EPA, 2009). Most of these are feasibility and not risked based. This figure is chosen because it is still analytically measurable but low enough to ensure health effects will not occur despite the uncertainties.

However, Salocks (2009a, 2009b) and Wright (2009) have used standard proven health-based risk assessment methodologies, for California and Australia respectively, in deriving HILs for surface methylamphetamine contamination for clan labs.

As a first step Salocks (2009a) developed a prolonged exposure (four month) reference dose (or tolerable daily intake) of 0.3 µg/kg/day. This was based on the lowest exposure level producing an adverse effect from previous human studies, and then dividing it by a composite 300 uncertainty factor related to influences such as variation in individual susceptibility. The reference dose is the amount of material which can be taken in on a prolonged basis at or below which deleterious health effects are not expected. In contrast, an illicit drug user may use 1500 µg/kg of methylamphetamine in a single daily dose.

Subsequently Salocks (2009b) determined the HIL for methylamphetamine to be 1.5 µg/100cm^2 based on the most susceptible exposed population being six months to two year old children. Despite the risk basis methodology for this level, there has been some criticism that some of its assumptions may have led to a higher figure (Ministry of Health, 2010). The HIL methodology assumed that remediation would be undertaken resulting in no ongoing reservoirs of contamination, and therefore that no exposure greater than four months or exposure to resuspended methylamphetamine particulate material would occur.

Wright's (2009) value was 0.5 µg/100 cm^2 using the same toxicology data and general approach but with a more conservative exposure model, which she describes as a "Reasonable Maximum Exposure" scenario. NZ has also adopted 0.5 µg/100cm^2 as its clean-up level (Ministry of Health, 2010).

Contaminant Levels and Effect Levels

The level at which methylamphetamine contamination will produce a health consequence is not known but the higher the level the greater the likelihood and potential severity of health effects.

As stated above, contaminant levels, while present to some degree in all clan labs, vary considerably and are situation dependent.

Applying US clan lab contamination data to Australian situations (in the absence of local data) can be tenuous, but more likely reliable where production methodologies and circumstances are comparable between the two countries. Such similarities exist are indicated earlier in this document. In the case of the surface methylamphetamine contamination mean of 511 µg/100cm^2 identified by Martyny *et al*, (2004b) for actual clan labs, this is about 300 and 1000 times higher than the Salocks (2009) and Wright (2009) HILs respectively, and even more so for the HILs of other US States. These multiples exceed the uncertainty and safety factors incorporated into the derivation of the HILs and thus equate the contamination to the lowest contaminations observed to cause adverse effects (where any effect is presumed adverse) seen in the corresponding small exposure studies for certain human populations, namely weight loss for some pregnant women (0.08 mg/kg-day) and sleep disturbance for some children (0.2 mg/kg-day). Adverse health effects could occur well below 511 µg/100cm^2 for larger exposed populations.

For higher levels of contamination there is potential for greater frequency and severity of these effects and also other adverse effects to emerge, such as to the central nervous and cardiovascular systems. Other adverse effects could have been produced at levels lower than 511 µg/100cm^2, but not monitored in the studies the HILs were based on.

In the case of the much greater number of **undetected** clan labs the risks to occupants and others visiting the residence will be substantially higher because prolonged exposure at resulting higher levels is expected to occur and also can involve the harmful gases associated with the manufacturing process. Furthermore, bulk chemicals may still be present on-site. People associated with undetected clan labs may be subject to two or more times the duration/dose exposure level than

would be found with people from “busted” labs, taking account of the above considerations especially clan lab operational timeframes (e.g. on average, a bust may halve these timeframes).
In the case of environmental contamination especially from dumped chemicals, the level of contamination *in situ* is likely to be well above effect levels at least for acute acting chemicals like sodium hydroxide.

Health Risk Estimation

As previously stated it is likely that many hundreds of children (about 10% toddlers) have/are being exposed to clan lab contamination and this is likely to be in terms of thousands if undetected clan labs are included (assuming a 1:10 ratio). The corresponding numbers of adults including other sensitive groups are likely to be even higher.

As many people may be exposed to methylamphetamine greatly above HIL levels, it is likely that significant proportions of them will be suffering some health effects ranging from subtle to more severe. These effects are likely to be greatest for groups associated with undetected labs, followed by un-remediated ones. However this data will be largely unrecognized and unreported.

It is worth noting that the usually more contaminating phosphorus-related methylamphetamine production methods which predominate in QLD, NSW, VIC and SA clan labs suggests that their exposed populations may be at several fold greater risk than those in WA where the Nazi/Birch reduction method is dominant. From 2010-2011 to 2011-2012, use of the phosphorus-related methods grew substantially, by more than 50% in some jurisdictions, although some annual variation is to be expected.

Although other inter-jurisdictional clan lab differences exist these are often on the margins of the available data and reliability can vary from year to year, for instance the production of MDMA, and also of methylamphetamine by the P-2-P method (ACC, 2012: ACC, 2013)

In the absence of additional detail, it is hard to gauge the public health risks that may arise in NSW where about 50% of the clan labs are medium or large in size (possibly in commercial-related sites), as compared with those in QLD and WA where they are 90% addict-based (primarily in residences).

Table 4 shows some speculative population sizes associated with clan lab activity and the possible corresponding level of risk. This is in terms of occupants of residences that have been used as clan labs, being the situation of most public health concern. It makes use of the clan lab quantitative data outlined earlier in the document, is for a one year period and assumes four people per residence (Howell, 2013). Numbers will obviously grow with time. The level of uncertainty in the risk ratings will be greatest for the undetected clan labs.

It is worth noting that up to one third of each population may be children. Also some groups may be involved in more than one exposure scenario.

Table 4 - Exposure Group Risk Ratings

Exposure Group	Population Size	Risk Rating*
Detected clan labs		
- Remediated – Post-operation[#]	100s?	1
- Un-remediated – Post-operation[#]	1000s	2
- Operational phase	1000s	4
Undetected clan labs		
- Operational phase	10,000s	5
- Post-operational	10,000s	3

* Risk is simply rated in order 1 (low i.e. even minor effects to susceptible groups unlikely) to 5 (highest i.e. minor or major health effects possible even for healthy adults)

[#] Assumes the current low level of remediation activity in Australia

The emphasis of this paper has focused on methylamphetamine production and exposure as a source of risk and primarily relates to typical situations in non-workplace settings that can be determined. The risks associated with other clan lab manufacturing methods and chemicals and possibly more severe circumstances is much harder to estimate but likely to be less common. Potential occupational and environmental exposures are considered to be a lesser concern as they are less likely to result in significant exposure when they occur.

However, it is apparent that thousands of Australians and are at some level of incidental public health risk from the illicit operations of clan labs, and this continues to increase.

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Website or link:
http://www.public.health.wa.gov.au/3/1653/2/clandestine_drug_laboratories.pm

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