Asthma mortality in Australia in the 21st century: a case series analysis

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ABSTRACT
Objective: As previous asthma mortality studies were undertaken between 1986 and 1997, and treatments have evolved since that time, in order to direct future asthma interventions, we investigated the reasons for asthma deaths between 2005 and 2009.

Design: We undertook a case series analysis by searching the National Coroners’ Information System using the most recent International Classification of Diseases-10 codes J45 and J46 and the keyword ‘asthma’ as the underlying cause of death.

Setting: Records for 283 cases aged 70 years and under were retrieved from each Australian state and territory. Coroner’s findings, autopsy, toxicology and police reports were reviewed to determine: if the team agreed the death was due to asthma and whether the death was preventable or modifiable factors existed?

Results: Examination of available data in those aged under 70 years identified risk factors associated with asthma death. These included physical barriers (rural and remote location, institutionalised care), psychosocial issues (social disengagement, mental illness, living alone, being unemployed), smoking, drug and alcohol dependence, allergies, respiratory tract infections, inadequate treatment and delay in seeking help.

Conclusions: Our study provides a current assessment of death from asthma across Australia. Further reductions in the rate of asthma deaths will require interventions targeted at the personal, practice and policy levels. Asthma-related health literacy needs to be improved especially among those with episodic asthma. Reforms are also needed to address inequity in healthcare delivery to ‘reach the unreached’. Our study points to the dangers associated with smoking, drug and alcohol use and the consequences of delay in seeking care among those with asthma.

BACKGROUND
The most recent record of Australian asthma deaths, in 2010, recorded asthma as the underlying cause for 416 deaths.1 This is an increase on the 385 deaths recorded in 20071 but a decrease on asthma deaths in 2008, where asthma was the underlying cause for 449 deaths.1 This rate of 1.6/100 000 people is high by international comparison.2

Pre-vious asthma mortality studies were undertaken between 1986 and 1997; asthma treatments have evolved since this time.

Methods

For numbered affiliations see end of article.

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ARTICLE SUMMARY

Article focus
● Despite classification as a National Health Priority and the introduction of National Asthma Guidelines in the 1990s, asthma is associated with a substantial impact on the community and asthma deaths remain high by international comparators.
● Previous asthma mortality studies were undertaken between 1986 and 1997; asthma treatments have evolved since this time.
● In order to direct future asthma interventions, we investigated reasons for asthma deaths between 2005 and 2009.

Key messages
● Our study is a current assessment of death from asthma across Australia.
● Asthma deaths in Australia are associated with health inequalities, drug and alcohol use, psychosocial issues, poor health literacy and social isolation.
● There is an urgent need for interventions that ‘reach the unreached’ by targeting practice and policy in addition to interventions at a personal level to improve asthma-related health literacy.
have died, we examined cases of asthma death reported to the Coroner and recorded on the National Coroners Information System (NCIS). The Coroner investigates ‘reportable’ deaths, that is, a death, that is, ‘unexpected’, ‘unnatural’, ‘violent’ or the death of those ‘in care’ at the time of death.

Usually a police officer or a medical practitioner will notify the Coroner of any death that may be ‘reportable’. However, any person may notify the Coroner if they believe that a reportable death has occurred. The role of the Coroner is to investigate the circumstances surrounding all ‘Reportable deaths’.

At the conclusion of every investigation, it is the task of the Coroner to prepare a written finding to establish wherever possible: the identity of the deceased; the circumstances surrounding the death; the cause of death; and the particulars needed to register the death. An autopsy, undertaken by a forensic pathologist, can help explain the cause of death and is part of the coronial investigation into ‘reportable’ deaths. As the next of kin has a legal right to file an objection to an autopsy being conducted, the Coroner will take into consideration any such objection, and therefore an autopsy is not always carried out. Once the pathologist has all the results of the tests, a detailed report is prepared for the Coroner, which outlines the medical findings and conclusions. The Coroner takes this information into account when making a finding. Once the Coroner has made a finding, the case is considered ‘closed’ and coded according to International Classification of Disease for the underlying cause of death.

We ascertained the number of asthma deaths recorded in each state and territory in Australia, between 2005 and 2009, using available Australian Bureau of Statistics and Australian Institute of Health and Welfare data (see tables 1 and 2). We then undertook a retrospective case series analysis by searching the NCIS using the most recent International Classification of Diseases (ICD-10) codes J45 and J46 and the keyword ‘asthma’ as the underlying cause of death. The Coroner’s findings, autopsy, toxicology and police reports were reviewed to determine: if the team agreed that death was due to asthma and whether it was preventable or modifiable factors existed. Cases of asthma deaths in those under 70 years of age that were deemed to be due to asthma were included in our analysis. The team consisted of three respiratory physicians, a medical sociologist and a research officer.

Demographic comorbidities, medication use and smoking history information were noted from available police, toxicology, autopsy reports or the Coroner’s findings. Preventable deaths were assessed on the basis of available details and consensus clinical judgement if different or specific actions had been taken and the death was likely to have been avoided. Modifiable factors...
associated with death were factors amenable to change and may have contributed to the fatal outcome.

**Data analysis**

**Socioeconomic status**

Socioeconomic status was determined using ABS-Socioeconomic Indices For Areas (SEIFA), a continuum of advantage (high values) to disadvantage (low values). SEIFA used a broad definition of relative socioeconomic disadvantage in terms of people’s access to material and social resources, and their ability to participate in society. Advantage/disadvantage classifications were derived from Census variables related to low income, low educational attainment, unemployment, dwellings without motor vehicles, high household income and tertiary education. SEIFA index scores were standardised to a mean of 1000. A lower score indicated an area of relative disadvantage compared to an area with a score higher than 1000.

**Exclusion criteria**

Owing to the likelihood of comorbidities or alternative diagnoses contributing to deaths in those over 70 years of age, this group was excluded.

**Figure 1** Flow diagram of cases examined.
cases and toxicological analysis in 159 (56%) cases (84/159 were accessible on NCIS). Tables 1 and 2 provide a breakdown of the overall death rate, age, gender and SEIFA classification of the cases examined.

**Preventable/modifiable deaths**
Preventable or modifiable factors were identified in 70% (169/243) of the cases examined. There was insufficient information to determine whether 28% (70) deaths were preventable or modifiable. Four cases were deemed as not preventable (see table 3 below).

**Case characteristics**
A slight majority, 126/243 (52%) deaths were male. The age range of cases was between 2 and 70 years of age with a mean (±SD) age 44±17 years. There was no association between age ($\chi^2=42.8, p=0.9$) or gender ($\chi^2=0.017, p=0.9$) and whether the asthma death was considered preventable or not.

**Location of death**
The majority of deaths, 145/243 (60%), occurred at home. For seven cases, home was a caravan. Twenty (8%) deaths occurred either at a hospital or a general practitioner’s Clinic, and 13 (4%) on the way to hospital. Eleven deaths (4%) occurred in public places (airport, school, bus stop, restaurant, street, workplace, camping ground). Six deaths (2%) occurred in residential institutions. The location of death was not available for 47 (19%) cases.

**Socioeconomic status**
One hundred and fifty-seven (65%) cases lived in areas classified as disadvantaged. The mean (±SD) SEIFA advantage/disadvantage classification of cases was 980±74. Of the 169 preventable or modifiable deaths, 106 (62%) were classified as disadvantaged. A slightly higher number of preventable deaths, 67% (106/157), occurred in those living in disadvantaged areas.

Only 91 (37%) of the deceased persons were employed at the time of death. Seventeen (7%) were women undertaking home duties, 61 (25%) were unemployed, 29 (12%) were retired, 19 (8%) were students and 2 (1%) were children under 5 years of age. There was no employment status listed for 24 (10%) cases.

**Psychosocial issues**
Psychosocial factors were identified in 106 (49%) cases. These factors included living alone, social disengagement and mental health issues. Mental illnesses included bipolar disorder, depression, schizophrenia, personality or compulsive obsessive disorders and anxiety.

**Drug and alcohol use/abuse**
Drug and alcohol abuse was identified as a factor contributing to death in 83 (34%) cases. Recreational/illicit drugs included opiates, methamphetamine, methadone, cannabis and alcohol (see table 4). Sixty (25%) case records identified the deceased as a smoker.

**Inadequate treatment/management**
Preventer medication ownership was recorded in 28% of cases. As information on asthma medicines was not routinely recorded, conclusions on under-or-overuse of therapy or financial barriers cannot be drawn.References to reliever/rescue medication use included ownership of a symptom modifier without an accompanying preventer, evidence of expired or empty rescue medication, inhalers/nebules strewn about the room and nebuliser machines still running.

Inadequate treatment was recorded in 43 (18%) cases. Inadequate treatment was not only related to poor self-management, but also included deficits in the provision

<table>
<thead>
<tr>
<th>Table 3 Characteristics of preventable/modifiable deaths</th>
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<tbody>
<tr>
<td>Preventable or modifiable factors (n=169)</td>
</tr>
<tr>
<td>Age (Mean±SD)</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>SEIFA</td>
</tr>
<tr>
<td>Location of death</td>
</tr>
<tr>
<td>Home/friends (n=145)</td>
</tr>
<tr>
<td>Hospital/GP (n=20)</td>
</tr>
<tr>
<td>Ambulance/on way to hospital (n=13)</td>
</tr>
<tr>
<td>Public place (n=11)</td>
</tr>
<tr>
<td>Residential care (n=6)</td>
</tr>
<tr>
<td>Missing (n=47)</td>
</tr>
<tr>
<td>Psychosocial issues (n=106)</td>
</tr>
<tr>
<td>Drug and alcohol abuse (n=83)</td>
</tr>
<tr>
<td>Delay in seeking help (n=63)</td>
</tr>
<tr>
<td>Respiratory tract infection (n=39)</td>
</tr>
<tr>
<td>Sudden onset (n=111)</td>
</tr>
</tbody>
</table>

SEIFA, Socioeconomic Index For Areas; GP, general practitioner.

of asthma care. It was not possible, in most cases, to determine written action plan ownership from this data set. Unfamiliarity with the individual’s asthma or experience with provision of asthma care by both health professionals and carers was a contributing factor to several deaths that occurred in the hospital, home and institutional settings.

Physical barriers
Rural or remote areas were the setting for 109 (45%) deaths attributed to asthma. Fourteen (6%) deceased persons were known to have had a physical and/or intellectual disability; five of these cases lived in residential care homes. One deceased person was in prison and unable to gain assistance during his fatal attack.

Delay in seeking help
In 73 (30%) cases, the deceased person was found after death. Sixty-three (26%) deceased persons were deemed to have delayed seeking assistance for their fatal asthma attack. In some cases, the failure to identify the seriousness of the asthma exacerbation was linked to drug and/or alcohol use. In some instances, the deceased was reported to have curled up on the couch or gone to bed feeling unwell and was later found dead. In the case of those who lived alone and were found dead, the deceased was discovered by a friend or relative or by police conducting a welfare check after referral from a concerned person.

Respiratory tract infections
In 39 (16%) cases, a respiratory tract infection was reported to be present prior to the fatal asthma attack. Death certificate information between 2003 and 2007 gave an acute respiratory infection as a comorbidity in 30% of deaths, and therefore our figure is very likely an underestimate. Seventy-seven (32%) cases of asthma death occurred in autumn and 63 (26%) in winter.

Sudden onset death/allergy/anaphylaxis
Fatal asthma attacks were categorised as sudden onset in 111 (46%) cases rather than a gradual deterioration, which has significance in that it may limit the time available to respond effectively. Specific exposures prior to onset were identified in 22 (9%) cases and included food, non-steroidal anti-inflammatory or β-blocker medication, exposure to smoke or fumes and exercise. Between 2005 and 2009, 27 deaths reported to the coroner were attributed to anaphylaxis. Although in 9 of these cases there was also a known history of asthma and allergy, as the death was coded as anaphylaxis, none of these 27 cases were included in this study.

DISCUSSION
Our retrospective study of asthma deaths between 2005 and 2009 is the most recent study of asthma deaths undertaken in Australia for nearly two decades, and the first to report asthma deaths across Australia. We revealed high specificity in the recording of asthma deaths, during examination of postmortem information and toxicology reports, to confirm that 243/283 (86%) deaths were due to asthma rather than having asthma as a comorbidity when another immediate cause of death existed. We considered that 70% of these deaths had preventable or modifiable factors.

Although there are similarities between our findings and preventable or modifiable factors reported in earlier studies, our findings provide a greater understanding of the current circumstances surrounding asthma deaths. Previous research identified inadequate assessment or therapy, delay in seeking help, smoking, alcohol abuse, family problems and psychiatric disorders as factors in asthma deaths. In addition to these factors, our findings identify disadvantage as an underlying theme among asthma deaths in Australia and a link between inequity, psychosocial issues, health literacy and social isolation. A further concern is the higher rate of asthma deaths among those residing in rural or remote areas (45%) given that only 32% of the overall

<table>
<thead>
<tr>
<th>Drug</th>
<th>n</th>
<th>Mean concentrations±SD</th>
<th>Normal values*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol—blood ethanol</td>
<td>32</td>
<td>0.09±0.09 g/100 ml</td>
<td>&lt;0.05 g/100 ml</td>
</tr>
<tr>
<td>Opiates/morphine/pethidine</td>
<td>8</td>
<td>6±7 mg/l</td>
<td>0.01–0.1 mg/l, 0.1–0.8 mg/l</td>
</tr>
<tr>
<td>Methadone</td>
<td>7</td>
<td>0.8±0.3 mg/l</td>
<td>0.1–0.5 mg/l</td>
</tr>
<tr>
<td>Amphetamine†</td>
<td>7</td>
<td>0.15±0.15 mg/l</td>
<td>0.02–0.1 mg/l</td>
</tr>
<tr>
<td>Tetrahydrocannabinol ‡</td>
<td>15</td>
<td>3±4.9 mg/l</td>
<td>0.005–0.01 mg/l</td>
</tr>
<tr>
<td>Ketamine</td>
<td>3</td>
<td>0.1, 0.7, 2.0 mg/l</td>
<td>1–6 mg/l</td>
</tr>
<tr>
<td>Caffeine</td>
<td>1</td>
<td>10 mg/l</td>
<td>4–10 mg/l</td>
</tr>
</tbody>
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Toxicology examination was performed in 159 cases; 84 of these reports were accessible.

Toxicology reports were not available for the 26 West Australian cases or 49 cases in other states.

*Therapeutic (normal), toxic and comatose-fatal blood-plasma concentrations (mg/l) in man.
†Amphetamine and/or methamphetamine.
‡Tetrahydrocannabinol.

Table 4 Toxicology results.
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Australian population live in rural or remote areas and asthma prevalence is higher in inner city areas. Previous population-based research has reported on the relationship between death rates and remoteness of residence between 2003 and 2007. In Australia, ‘Medicare’, a universal Government-operated public healthcare system, provides free or subsidised treatment by doctors and specialists and free treatment as a public patient in a public hospital. Despite this, equity of access to healthcare services, physical distance and poor access to health services were clearly factors in some cases that were examined; owing to the nature of our data set, however, we are unable to generalise about these findings.

The conditions in which people live and work can lead to inequities in power and resources and consequently to health inequalities. Although socioeconomic status and geographic location have previously been related to increased risks of death from asthma, our study confirms higher rates of asthma deaths among those living in areas of disadvantage, not in the workforce and/or living in rural or remote areas and among those with psychosocial issues. Two-thirds of the asthma deaths we investigated occurred in people from disadvantaged areas.

Drug and alcohol use and smoking were very high in cases of asthma death compared with the general population during the period of our investigation. A third of the cases examined used alcohol or illicit drugs prior to death compared to 9% and 13%, respectively, in the general population over 14 years of age at this same time. Similarly, smoking rates were 25% compared with 17%. Not all toxicology reports were available for examination electronically, and therefore actual drug and alcohol usage may be higher.

According to information in police reports and coroners’ findings, the concentrations of drugs observed in asthma deaths were not all at toxic levels. Although above the legal limit of 0.05 g/100 ml, the average blood alcohol level of 0.09 g/100 ml is below toxic levels. However, the average opiates levels, including morphine, pethidine and methadone in the group we studied, are all in excess of known toxic levels, indicating association of these drugs with death. It is likely that drug use, especially opiates, has a role in exacerbating asthma and not perceived as a risk or reason to seek asthma care. Previous research by our team that demonstrated differing perceptions of ‘what constitutes an asthma attack’ also added evidence that for many people, despite preventive therapy use, a respiratory viral infection may result in an asthma episode that they are ‘unable to control’. A recent study evaluating the effect of different asthma treatments on common cold-related asthma exacerbations found that severe exacerbations were reduced by budesonide/formoterol maintenance therapy and emphasised the role of inhaled corticosteroids.

Unfamiliarity with the individual and their particular asthma needs was a factor that led to inadequate...
Asthma mortality in Australia in the 21st century


Our retrospective study provides a current assessment of ‘reportable’ asthma deaths across Australia. Seventy per cent of these deaths were considered preventable and our findings suggest that to achieve further reductions in the rate of asthma deaths in Australia, among those aged under 70 years of age, multifaceted interventions targeted at the personal, practice and policy levels will be required.

At the personal level, improvement in asthma health literacy among those with infrequent asthma is required to identify and manage worsening symptoms and the risks associated with delay in seeking care. Parents and carers should also develop confidence to manage an attack, implement an emergency plan and to recognise when it is appropriate for them to take control if the person experiencing an asthma exacerbation fails to do so. The delivery of home-based self-management education could be appropriate to reach those who are frail, house-bound and/or socially isolated. E-health technologies should also be considered as a means of delivering education and advice to those living in areas where geographical distance is problematic.

Health professionals working in primary care settings need to ensure that all patients, not just those with moderate to severe asthma, receive comprehensive asthma education, a written Asthma Action Plan and advice about the potential risk of delay in seeking care. Quality Awards system, such as those operating in the UK, could be introduced to encourage delivery of guideline-based asthma care in Australian practices.

At the policy level, current asthma guidelines need to highlight issues associated with asthma management in those with psychosocial problems, including drug and alcohol addiction, given that both are problematic and widespread. Provision of asthma education and a written asthma action plan should also be mandatory for those who present to emergency departments.

Interventions that specifically target community needs are also required. Reforms are needed to address inequity in healthcare delivery to ‘reach the unreached’ as well as raising the awareness of dangers associated with smoking, drug and alcohol use and the consequences of delay in seeking care for those with asthma. A recent method of engaging communities has been the use of performance to raise awareness and deliver health messages. These plays can be performed in a variety of settings, including schools, pubs, seniors clubs and conferences. The recently introduced Medicare Local network in Australia is very likely a place to determine a need.

Future research

A case control study of asthma deaths in Australia is required. It should investigate deaths across all age groups, the circumstances surrounding the death as well as the management of fatal attacks and the quality of care in the preceding 12 months such as that currently being undertaken in the UK.

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Contributors DG and JD conceived the idea of the study. DG, JD and MA were responsible for the design of the study. DG, EM, JD, CZ and MA were responsible for undertaking the data analysis. DG and EM produced the tables
and graphs. The initial draft of the manuscript was prepared by DG and then circulated repeatedly among all authors for critical revision. DG was responsible for the acquisition of the data and all authors contributed to the interpretation of the results. All authors approved the final version for publication.

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