



Asthma Mortality in Australia in the 21st Century: a case series analysis

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Asthma Mortality in Australia in the 21st Century: a case series analysis

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Keywords: Asthma mortality, self-management, health-literacy, access to healthcare, psychosocial issues.

(word count 3000)

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 reasons for asthma deaths between 2005 and 2009.

Design

We undertook a case series analysis by searching the National Coroners' Information System (NCIS)⁸ using the most recent International Classification of Diseases (ICD-10) codes J45 & J46⁹ and the keyword 'asthma' as the underlying cause of death.

Setting

Records for 283 cases aged 70 years and under, from across each Australian state and territory, were retrieved. 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? Due to the likelihood of co-morbidities or alternative diagnoses contributing to deaths in those over 70 years of age, this group was excluded.

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.

Conclusion

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 health care delivery to 'reach the un-reached'. Our study points to the dangers associated with smoking, drug and alcohol use and the consequences of delay in seeking care in those with asthma.

(288 words)

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 remains 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 linked to health inequalities, drug and alcohol use, psychosocial issues, poor health literacy and social isolation
- There is an urgent need for interventions that ‘reach the un-reached’ by targeting the practice and policy levels in addition to interventions at the personal level that aim to improve asthma related health literacy.

Strengths and limitations

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 confirmed that 243/283 deaths were due to asthma rather than having asthma as a co-morbidity when another immediate cause of death existed. We identified that 70% of these deaths had preventable or modifiable factors.

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4 Recently introduced privacy laws prevent use of Death registries in Australia for the
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6 purpose of identifying individuals who have died. Our study therefore differs to the
7
8 previous mortality studies in that we used the NCIS to identify asthma deaths.
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11 Limitations of our data include the examination of only those asthma deaths that were
12
13 reported to the Coroner. The Coroner investigates 'reportable' deaths that is, a death
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15 that is 'unexpected' 'unnatural', 'violent' or the death of those 'in care' at the time of
16
17 death. Thus cases are likely to be biased toward younger people or those
18
19 institutionalised at the time of death. Anticipated deaths from asthma would not have
20
21 been reported and as a consequence our study may under-estimate this group. As
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23 cause of death analysis focuses on only one underlying cause rather than multiple
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25 causes of death, the overall contribution of asthma to adult deaths in Australia is also
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27 likely to be underestimated.
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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 comparators.²

Previous asthma mortality studies were undertaken in Victoria and South Australia during the late 1980s and the 1990s.^{3,4,5,6} As the pattern of asthma deaths may have changed over the last decade and more effective medications are now available we undertook a study of deaths between 2005 and 2009 to discover the current circumstances surrounding the deaths and to identify potential interventions.

METHODS

Data collection

We ascertained the number of asthma deaths recorded in each state and territory in Australia since 2005 using available Australian Bureau of Statistics¹ and Australian Institute of Health and Welfare (AIHW) data (see tables 1 & 2).⁷

We then undertook a case series analysis by searching the National Coroners' Information System (NCIS)⁸ using the most recent International Classification of Diseases (ICD-10) codes J45 & J46⁹ and the keyword 'asthma' as the underlying cause of death. Coroner's findings, autopsy, toxicology and police reports were reviewed to determine: if the team agreed the death was due to asthma and whether

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4 the death was preventable or modifiable factors existed? The team consisted of three
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6 respiratory physicians, a medical sociologist and a research officer. Due to the
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8 likelihood of co-morbidities or alternative diagnoses contributing to deaths in those
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10 over 70 years of age, this group was excluded.
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15 Demographic, co-morbidities, medication use and smoking history information were
16
17 noted from available police, toxicology, autopsy reports or Coroner's findings.
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19 Preventable deaths were assessed on the basis of available details, and consensus
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21 clinical judgement if different or specific actions had been taken and the death was
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23 likely to have been avoided. Modifiable factors associated with the death were factors
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25 amendable to change and that may have contributed to the fatal outcome.
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31 **Data analysis**

32 *Socio-economic status*

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35 Socio-economic status (SES) was determined using ABS-Socio Economic Indices For
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37 Areas (SEIFA) advantage/disadvantage classification.¹⁰ SEIFA index scores are
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39 standardised to a mean of 1000. A lower score indicated an area of relative
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41 disadvantage compared to an area with a score higher than 1000.
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46 *Statistical analysis*

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48 Descriptive analysis was performed using SPSS version 20 (Statistical Package for
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50 Social Scientists, IBM Corporation 2011). Chi-square was used to test differences of
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52 proportions.
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56 **Ethics**

The Alfred Hospital Human Research and The Department of Justice Ethics Committees approved the study.

RESULTS

Data

The Justice Department granted permission to access data for closed cases across Australia. West Australian data (26 cases) were restricted to non-identifying demographic information. Of 557 asthma deaths in those under 70 years of age between 2005 and 2009, we retrieved 283(51%) cases (see tables 1 & 2).

Table 1: Asthma deaths/rate per 100,000 in Australia by age from 2005 to 2009

Age	2005	2006	2007	2008	Overall
0-9	3	0	1	7	11
10-19	4	5	4	4	17
20-29	14	11	16	9	50
30-39	11	8	15	23	57
40-49	34	22	24	25	105
50-59	22	27	32	36	117
60-69	39	56	52	53	200
Total under 70 years	127	129	144	157	557
70-79	47	68	53	61	229
80-89	144	205	188	229	766
Total 70 years & over	191	273	241	290	995
Overall deaths and rate per 100,000	318(1.5%)	402(1.8%)	385(1.7%)	449(1.9%)	1552

Source: Australian Bureau of Statistics. Causes of Death 2010.

Table 2: Deaths due to asthma (J45,J46) by sex, age group and state/territory for 2005-2009

Year	Females			Male		
	Under 70	70 or more	All ages	Under 70	70 or more	All ages
New South Wales						
2005	18	49	67	24	14	38
2006	24	68	92	19	32	51
2007	22	59	81	31	27	58
2008	30	63	93	25	27	52
Victoria						
2005	21	40	61	7	16	23
2006	18	46	64	14	18	32
2007	22	53	75	10	15	25
2008	18	73	91	8	21	29
Queensland						
2005	12	28	40	15	8	23
2006	12	29	41	8	18	26
2007	15	26	41	11	12	23
2008	13	27	40	24	14	38
South Australia						
2005	7	13	20	3	4	7
2006	11	20	31	6	8	14
2007	12	16	28	6	7	13
2008	8	13	21	12	13	25
Western Australia						
2005	7	10	17	9	4	13
2006	8	12	20	6	7	13
2007	8	12	20	7	4	11
2008	3	16	19	4	5	9
Tasmania						
2005–2007	3	18	21	3	4	7
2008–2010	8	27	35	4	13	17
Northern Territory						
2005–2010	-	-	9	3	4	7
Australian Capital Territory						
2005–2007	3	6	9	5	4	9
2008–2010	3	9	12			

Source: Analysis of Australian Institute of Health and Welfare National Mortality Database

Note: One death excluded from tabulation due to missing area of usual residence. Tasmania, NT, ACT reported from 2005-2010 due to small numbers/issues of identification

Two-hundred and forty-three cases had sufficient documentation to determine the main cause of death as asthma (see table 3). An autopsy had been conducted in

209(86%) cases and toxicological analysis in 159(56%) cases (84/159 were accessible).

Table 3: Cases examined from NCIS between 2005 and 2009 by age, gender and SEIFA

	2005	2006	2007	2008	Overall
Age					
0-9	2	0	1	6	9
10-19	3	3	2	4	12
20-29	9	8	12	2	31
30-39	8	5	9	13	35
40-49	20	13	11	10	54
50-59	12	18	8	15	53
60-69	16	11	12	9	48
Total under 70	70	58	56	59	243
Gender					
Male	39	25	28	34	126
Female	31	33	28	25	117
Total	70	58	56	59	243
SEIFA					
-1000	45 (18%)	33 (14%)	38 (16%)	41 (17%)	157 (65%)
+1000	24 (10%)	25 (10%)	18 (7%)	18 (7%)	85 (35%)
Missing	1				
Total	70	58	56	59	243

Preventable / modifiable deaths

One hundred and sixty-nine of the 243(70%) cases examined were deemed to be preventable or have modifiable factors. There was insufficient information to determine whether 70(28%) deaths were preventable or modifiable.

Case characteristics

A slight majority, 126/243(52%) of deaths were male. The age range of cases was between 2 and 70 years of age with a mean (\pm 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.

Location of death

The majority of deaths 148/243(60%) occurred at home. For seven cases, home was a caravan. Twenty (8%) deaths occurred either at a hospital or GP 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.

Socio-economic status

One hundred and fifty-seven (65%) of cases lived in areas classified as disadvantaged. The mean (\pm SD) SEIFA advantage/disadvantage classification of cases was 980 ± 74 . Of the 169 preventable or modifiable deaths, 106(62%) were classified as disadvantaged.

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%) of cases. These factors included living alone, social disengagement and mental health issues. Mental illnesses included bi-polar 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, methamphetamines, methadone, cannabis and alcohol (see table 4). Sixty (25%) case records identified the deceased as a smoker.

Table 4: Toxicology results

Drug	n	Average concentration \pm Std Deviation
Alcohol - Blood ethanol	32	0.09 \pm 0.09mg/L
Opiates/Morphine/Pethidine	8	6 \pm 7mg/L
Methadone	7	0.8 \pm 0.3mg/L
Amphetamine*	7	0.15 \pm 0.15mg/L
Cannabis ^	15	3 \pm 4.9mg/L
Ketamine	3	0.1, 0.7, 2.0mg/L
Caffeine	1	10mg/L

*Amphetamine and/or methamphetamine

^ Tetrahydrocannabinol

Toxicology examination was performed in 159 cases, 84 of these reports were accessible.

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

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 nebulizer machines still running.

Inadequate treatment was recorded in 43(18%) cases. Inadequate treatment was not only related to poor self-management, but included deficits in the provision of asthma care. It was not possible to determine written action plan ownership from this data set. Unfamiliarity with the individual's asthma or inexperience 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 setting.

Physical barriers

Rural or remote areas were the setting for 109(45%) of 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

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3 drug and/or alcohol use. In some instances the deceased was reported to have curled up on
4
5 the couch or gone to bed feeling unwell and later found dead. In the case of those who lived
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7 alone and found dead, the deceased was discovered by a friend or relative or by police
8
9 conducting a welfare check after referral from a concerned person.
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11 12 13 14 **Respiratory tract infections**

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16 In 39(16%) cases a respiratory tract infection was reported as present prior to the fatal asthma
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18 attack. Death certificate information between 2003 and 2007 an acute respiratory infection as
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20 a co-morbidity in 30% of deaths², therefore our figure is likely an underestimate. Seventy-
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22 seven (32%) cases of asthma death occurred in autumn and 63(26%) in winter.
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27 28 **Sudden onset death/ allergy/ anaphylaxis**

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30 One hundred and eleven (46%) fatal asthma attacks were categorised as sudden onset rather
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32 than a gradual deterioration, which has significance in that it may limit the time available to
33
34 effectively respond. Specific exposures prior to onset were identified in 22(9%) of cases and
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36 included food, non-steroidal anti-inflammatory or β -blocker medication, exposure to smoke
37
38 or fumes and exercise. Between 2005 and 2009, 27 deaths reported to the coroner were
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40 attributed to anaphylaxis. Although in 9 of these cases there was also a known history of
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42 asthma and allergy, as the death was coded as anaphylaxis, none of these 27 cases are
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44 included in this study.
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49 50 **DISCUSSION**

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52 Our retrospective study of asthma deaths between 2005 and 2009 is the most recent study of
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54 asthma deaths undertaken in Australia for nearly two decades, and the first to report asthma
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56 deaths across Australia. We confirmed that 243/283 deaths were due to asthma rather than
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3 having asthma as a co-morbidity when another immediate cause of death existed. We
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5 considered that 70% of these deaths had preventable or modifiable factors.
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10 Although there are similarities between our findings and preventable or modifiable factors
11 reported in earlier studies^{3,4,5,6} our findings provide a greater understanding of the current
12 circumstances surrounding asthma deaths. Previous research identified inadequate assessment
13 or therapy, delay in seeking help,^{3,4} smoking, alcohol abuse, family problems,⁵ and
14 psychiatric disorders as factors in asthma deaths.⁶ In addition to these factors, our findings
15 identify disadvantage as an underlying theme among asthma deaths in Australia and a link
16 between inequity, psychosocial issues, health literacy and social isolation. A further concern
17 is the higher rate of asthma deaths among those residing in rural or remote areas (45%) given
18 that only 32% of the overall Australian population live in rural or remote areas.¹¹
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32 The conditions in which people live and work can lead to inequities in power and resources
33 and consequently to health inequities.¹² Although socio-economic status and geographic
34 location, have previously been related to increased risks of death from asthma^{13,14} our study
35 confirms higher rates of asthma deaths in those living in areas of disadvantage, not in the
36 workforce and/or living in rural or remote areas, and among those with psychosocial issues.
37
38 Two-thirds of the asthma deaths we investigated occurred in people from disadvantaged areas.
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40 Drug and alcohol use and smoking were very high in cases of asthma death compared with
41 the general population during the period of our investigation. A third of cases examined used
42 alcohol or illicit drugs prior to death compared to 9% and 13% respectively in the general
43 population over 14 years of age at this same time. Similarly, smoking rates were 25%
44 compared with 17%. Not all toxicology reports were available for examination therefore
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60 actual drug and alcohol usage may be higher.

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5 According to information in police reports and coroners findings, the concentrations of drugs
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7 observed in asthma deaths were not all at toxic levels. The average blood alcohol level of
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9 0.09 mg/L is below toxic levels.¹⁵ However, the average opiate level including morphine,
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11 pethidine and methadone in the group we studied, are all in excess of known toxic levels¹⁵,
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13 indicating association of these drugs with death. It is likely that drug use, especially opiate
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15 use, to toxic levels, is responsible for a failure to recognize worsening asthma and not
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17 perceiving the risk of delay in seeking treatment. Given the known pharmacologic effects of
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19 these drugs on histamine release it is possible that the narcotic use is particularly problematic
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21 in the presence of asthma and physicians prescribing these drugs should be aware of this.
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23 Previous research undertaken in the United States (US) also identified illicit drug use as a
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25 significant factor in cases of asthma deaths under 46 years of age and implied that the
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27 increase in asthma deaths in the US may be a reflection of substance abuse and ethanol
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29 consumption.¹⁶ Our data confirm these findings.
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36 A study investigating the involvement of β_2 -agonists and asthma deaths also reported the
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38 presence in blood of ethanol, benzodiazepines, anti-depressants or antipsychotic medications,
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40 morphine, diazepam, codeine, methadone as well as illicit substances such as amphetamine,
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42 methamphetamine and cannabis.¹⁷ The author concluded that although alcohol probably does
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44 not precipitate asthma, sulphites present in some forms of alcohol may trigger asthma in
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46 susceptible patients. Furthermore the use of morphine was contraindicated in conditions such
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48 as acute bronchial asthma as it may produce respiratory depression resulting in increased
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50 arterial PaCO₂.¹⁷
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3 Our study identified a sub-set of apparently sudden onset asthma with rapid deterioration to
4 death. The fact that eleven deaths occurred in public places indicates the nature of rapid-onset
5 asthma attacks. Research has revealed that slow on-set asthma attacks of near fatal asthma
6 and rapid onset attacks may have different trigger factors, with allergens a likely trigger in
7 rapid onset and infection in slow onset attacks.^{18,19} James *et al*, have also reported on the
8 dichotomy of time to death and the eosinophil/neutrophil ratio in cases of asthma and of the
9 presence of muscle shortening in short course cases (< 3 hours) and accumulation of mucus
10 in long course cases (>8 hours).²⁰ Mode of onset and mechanism to death vary with asthma
11 and thus medical interventions, both acute and long term as well as more global strategies to
12 minimise risk will need to allow for this.
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27 Several deaths were likely due to acute hypersensitivity reactions including beta-blocker eye
28 drops and non-steroidal anti-inflammatory treatments. Our findings should alert practitioners
29 to the possible adverse consequences of prescribing these agents in asthma and highlight the
30 importance of an asthma action plan to advise patients to act in the event of asthma
31 worsening.
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41 Respiratory viral infections, recognised as the most important causes of asthma exacerbations
42 in both children and adults, emergency department attendances^{21,22} and hospitalisation
43 admissions in older people during winter² were a precursor to many fatal asthma
44 exacerbations but often not perceived as a risk or reason to seek asthma care. Previous
45 research by our team that demonstrated differing perceptions of ‘what constitutes an asthma
46 attack’ also added evidence that for many people despite preventive therapy use, a respiratory
47 viral infection, may result in an asthma episode that they are ‘unable to control’.^{23,21} A recent
48 study evaluating the effect of different asthma treatments on common cold-related asthma
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3 exacerbations found severe cold-related exacerbations were reduced by
4 budesonide/formoterol maintenance and therapy the role of inhaled corticosteroids is
5 emphasised.²⁴
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11 Un-familiarity with the individual and their particular asthma needs was a factor that led to
12 inadequate treatment by health professionals and carers in the hospital, the home and the
13 institutions. This demonstrated the importance of not only continuity of care but tailored care.
14 In the case of children this may require parents and/or carers taking on a more assertive role.
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23 Ownership of written action plans has declined, despite their being protective against asthma
24 death⁵ and research reporting ownership as useful.²² In 2007-2008 less than 20% of the
25 population with asthma were reported to own one.² Education, especially if delivered with a
26 written asthma action plan, will assist in the recognition of asthma exacerbations, appropriate
27 emergency asthma management and seeking care in a timely fashion. The delivery of home-
28 based person-centred asthma self-management education utilising the recently developed
29 Patient Asthma Concerns Tool (PACT) has also proven successful in those over 50 year of
30 age.^{25,26}
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43 *Study limitations*

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45 Recently introduced privacy laws prevent use of Death registries in Australia for the purpose
46 of identifying individuals who have died. Our study therefore differs to the previous mortality
47 studies in that we used the NCIS to identify asthma deaths. Limitations of our data include
48 the examination of only those asthma deaths that were reported to the Coroner. The Coroner
49 investigates 'reportable' deaths that is, a death that is 'unexpected' 'unnatural', 'violent' or
50 the death of those 'in care' at the time of death. Thus cases are likely to be biased toward
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3 younger people or those institutionalised at the time of death. Anticipated deaths from
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5 asthma would not have been reported and as a consequence our study may under-estimate
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7 this group. As cause of death analysis focuses on only one underlying cause rather than
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9 multiple causes of death, the overall contribution of asthma to adult deaths in Australia is also
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11 likely to be underestimated.²⁷
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13

14 15 16 **Conclusion**

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18 Our retrospective study provides a current assessment of death from asthma across Australia.
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20 Further reductions in the rate of asthma deaths in Australia, in those aged under 70 years of
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22 age, will require multi-faceted interventions targeted at the personal, practice and policy
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24 levels.
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29 At the personal level, improvement in the asthma health literacy among those with infrequent
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31 asthma is required to identify and manage worsening symptoms, and the risks associated with
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33 delay in seeking care. Parents and carers should also develop confidence to manage an attack,
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35 implement an emergency plan and to recognise when it is appropriate for them to take control
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37 if the person experiencing an asthma exacerbation fails to do so. The delivery of home-based
38
39 self-management education could be appropriate to reach those who are frail, house-bound
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41 and/or socially isolated. E-health technologies should also be considered as a means for
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43 delivering education and advice for those living in areas where geographical distance is
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45 problematic.
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51 Health professionals working in primary care settings need to ensure all patients, not just
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53 those with moderate to severe asthma, receive comprehensive asthma education, a written
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55 Asthma Action Plan and advice about the potential risk of delay in seeking care. Quality
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3 Awards system, such as those operating in the UK, could be introduced to encourage delivery
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5 of guideline based asthma care in Australian practices.²⁸
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10 At the policy level, current asthma guidelines need to highlight issues associated with asthma
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12 management in those with psycho-social problems, including drug and alcohol addiction
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14 given that both are problematic and widespread. Provision of asthma education and a written
15
16 asthma action plan should also be mandatory to those who present to emergency departments.
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20 Interventions that specifically target community needs are also required. Reforms are needed
21
22 to address inequity in health care delivery to 'reach the un-reached' as well as raising
23
24 awareness of dangers associated with smoking, drug and alcohol use and the consequences of
25
26 delay in seeking care for those with asthma. A recent method of engaging communities has
27
28 been the use of performance ²⁹ to raise awareness and deliver health messages. These plays
29
30 can be performed in a variety of settings, including schools, pubs, seniors clubs and
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32 conferences. The recently introduced Medicare Local network in Australia is likely a place to
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34 determine a need.
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40 **Future research**

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42 Future research into asthma mortality in Australia should consider a prospective 12 month
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44 national review of all asthma deaths. The review should investigate asthma deaths across all
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46 age groups, the circumstances surrounding the death as well as the management of fatal
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48 attacks and the quality of care in the preceding 12 months such as that currently being
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50 undertaken in the United Kingdom.³⁰
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CONTRIBUTORSHIP STATEMENT

DG & JD conceived the idea of the study and DG, JD and MA were responsible for the design of the study. DG, EM, JD, CZ and MA were responsible for undertaking for the data analysis and 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.

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No additional data available.

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Asthma Mortality in Australia in the 21st Century: a case series analysis

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Asthma Mortality in Australia in the 21st Century: a case series analysis

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Keywords: Asthma mortality, self-management, health-literacy, access to healthcare, psychosocial issues.

(word count 3637)

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 reasons for asthma deaths between 2005 and 2009.

Design

We undertook a case series analysis by searching the National Coroners' Information System (NCIS) using the most recent International Classification of Diseases (ICD-10) codes J45 & 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? Due to the likelihood of co-morbidities or alternative diagnoses contributing to deaths in those over 70 years of age, this group was excluded.

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.

Conclusion

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 health care delivery to 'reach the un-reached'. 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.

(286 words)

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 remains 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 un-reached’ by targeting practice and policy in addition to interventions at a personal level to improve asthma related health literacy.

Strengths and limitations

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 confirmed that 243/283 deaths were due to asthma rather than having asthma as a co-morbidity when another immediate cause of death existed. We identified preventable or modifiable factors in 70% of these deaths.

Recently introduced privacy laws prevent use of death registries in Australia for the purpose of identifying individuals who have died. Our study therefore differs to the previous mortality studies in that we used the NCIS to identify asthma deaths. Limitations of our data include

1
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3 the examination of only those asthma deaths that were reported to the Coroner. The Coroner
4 investigates 'reportable' deaths that is, a death that is 'unexpected' 'unnatural', 'violent' or
5
6 the death of those 'in care' at the time of death. Thus cases are likely to be biased toward
7
8 younger people or those institutionalised at the time of death. Anticipated deaths from
9
10 asthma would not have been reported and as a consequence our study may under-estimate
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12 this group. As cause of death analysis focuses on only one underlying cause rather than
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14 multiple causes of death, the overall contribution of asthma to adult deaths in Australia is also
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16 likely to be underestimated.
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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

Previous asthma mortality studies were undertaken in Victoria and South Australia during the late 1980s and the 1990s.^{3,4,5,6} As the pattern of asthma deaths may have changed over the last decade and more effective medications are now available, we undertook a study of deaths between 2005 and 2009 to discover the current circumstances surrounding the deaths and to identify potential interventions.

METHODS

Data collection

As recently introduced privacy laws prevent use of Death registries in Australia for the purpose of identifying individuals who 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'.

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3 At the conclusion of every investigation, it is the task of the Coroner to prepare a written
4 finding to establish wherever possible: the identity of the deceased; the circumstances
5 surrounding the death; the cause of death; and the particulars needed to register the death. An
6 autopsy, undertaken by a forensic pathologist, can help explain the cause of death and is part
7 of the coronial investigation into 'reportable' deaths. As the next of kin has a legal right to
8 file an objection to an autopsy being conducted the Coroner will take into consideration any
9 such objection and therefore an autopsy is not always carried out. Once the pathologist has all
10 the results of the tests, a detailed report is prepared for the Coroner, which outlines medical
11 findings and conclusions. The Coroner takes this information into account when making a
12 finding. Once the Coroner has made a finding, the case is considered "closed" and coded
13 according to International Classification of Disease for the underlying cause of death.
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29 We ascertained the number of asthma deaths recorded in each state and territory in Australia,
30 between 2005 and 2009, using available Australian Bureau of Statistics¹ and Australian
31 Institute of Health and Welfare (AIHW) data (see tables 1 & 2).⁷
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39 We then undertook a retrospective case series analysis by searching the National Coroners'
40 Information System (NCIS)⁸ using the most recent International Classification of Diseases
41 (ICD-10) codes J45 & J46⁹ and the keyword 'asthma' as the underlying cause of death.
42 Coroner's findings, autopsy, toxicology and police reports were reviewed to determine: if the
43 team agreed the death was due to asthma and whether the death was preventable or
44 modifiable factors existed? Cases of asthma deaths in those under 70 years of age that were
45 deemed to be due to asthma were included in our analysis. The team consisted of three
46 respiratory physicians, a medical sociologist and a research officer.
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3 Demographic, co-morbidities, medication use and smoking history information were noted
4 from available police, toxicology, autopsy reports or Coroner's findings. Preventable deaths
5 were assessed on the basis of available details, and consensus clinical judgement if different
6 or specific actions had been taken and the death was likely to have been avoided. Modifiable
7 factors associated with the death were factors amendable to change and that may have
8 contributed to the fatal outcome.
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19 **Data analysis**

20 *Socio-economic status*

21 Socio-economic status (SES) was determined using ABS-Socio Economic Indices For Areas
22 (SEIFA) a continuum of advantage (high values) to disadvantage (low values). SEIFA used a
23 broad definition of relative socio-economic disadvantage in terms of people's access to
24 material and social resources, and their ability to participate in society.
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30 Advantage/disadvantage classifications were derived from Census variables related to low
31 income, low educational attainment, unemployment, dwellings without motor vehicles, high
32 household income and tertiary education.¹⁰ SEIFA index scores were standardised to a mean
33 of 1000. A lower score indicated an area of relative disadvantage compared to an area with a
34 score higher than 1000
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45 *Exclusion criteria*

46 Due to the likelihood of co-morbidities or alternative diagnoses contributing to deaths in
47 those over 70 years of age, this group was excluded.
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54 *Statistical analysis*

55 Descriptive analysis was performed using SPSS version 20 (Statistical Package for Social
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Sciences, IBM Corporation 2011). Chi-square was used to test differences of proportions.

Ethics

The Alfred Hospital Human Research and the Department of Justice Ethics Committees approved the study.

RESULTS

Data

The Justice Department granted permission to access data for closed cases, that is cases where the Coroner had made a finding, across Australia. West Australian data (26 cases) were restricted to non-identifying demographic information. Of 557 asthma deaths in those under 70 years of age between 2005 and 2009, we retrieved 283(51%) cases (see fig 1).

Sufficient information was available (Coroners findings, autopsy, toxicology and police reports) to determine the main cause of death as asthma in 243 of the 283 cases. An autopsy had been conducted in 209(86%) cases and toxicological analysis in 159(56%) cases (84/159 were accessible on the NCIS). Tables 1 and 2 provide a breakdown of the overall death rate, age, gender and SEIFA classification of the cases examined.

Table 1: Asthma deaths/rate per 100,000 in Australia by age from 2005 to 2009

Age	2005	2006	2007	2008	Overall
0-9	3	0	1	7	11
10-19	4	5	4	4	17
20-29	14	11	16	9	50
30-39	11	8	15	23	57
40-49	34	22	24	25	105
50-59	22	27	32	36	117
60-69	39	56	52	53	200
Total under 70 years	127	129	144	157	557
70-79	47	68	53	61	229
80-89	144	205	188	229	766
Total 70 years & over	191	273	241	290	995

Overall deaths and rate per 100,000/year 318 (1.5) 402(1.8) 385 (1.7) 449 (1.9) 1552

Source: Australian Bureau of Statistics. Causes of Death 2010.

Table 2: Cases deemed to be asthma deaths examined from NCIS between 2005 and 2009 by age, gender and Socioeconomic Index For Areas (SEIFA)

	2005	2006	2007	2008	Overall
Age					
0-9	2	0	1	6	9
10-19	3	3	2	4	12
20-29	9	8	12	2	31
30-39	8	5	9	13	35
40-49	20	13	11	10	54
50-59	12	18	8	15	53
60-69	16	11	12	9	48
Total under 70	70	58	56	59	243
Gender					
Male	39	25	28	34	126
Female	31	33	28	25	117
Total	70	58	56	59	243
SEIFA					
-1000	18% (45)	14% (33)	16% (38)	17% (41)	65% (157)
+1000	10% (24)	10% (25)	7% (18)	7% (18)	35% (85)
Missing	1				
Total	70	58	56	59	243

Preventable / modifiable deaths

Preventable or have 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.

Table 3: Characteristics of preventable / modifiable deaths

	Preventable or Modifiable factors (n =169)	Non-preventable or modifiable factors (n=4)	Insufficient data to determine if death was preventable (n = 70)
Age	43 ± 17	57 ± 10	46 ± 17
Gender	90M 79F	2M 2F	34M 36F
SEIFA	985 ± 74	980 ± 98	968 ± 70
Location of death			

Home/friends (n=145)	122 (84%)	4 (3%)	19 (13%)
Hospital/GP (n=20)	14 (70%)	0	6 (30%)
Ambulance/on way to hospital (n=13)	12 (92%)	0	1 (8%)
Public place (n=11)	11 (100%)	0	0
Residential care (n=6)	3 (50%)	0	3 (50%)
Missing (n=47)	8 (17%)	0	39 (83%)
Psychosocial issues (n=106)	93 (88%)	2 (2%)	11 (10%)
Drug & Alcohol abuse (n = 83)	78 (85%)	1 (1%)	4 (4%)
Delay in seeking help (n =63)	57 (89%)		6 (9%)
Respiratory Tract Infection (n =39)	31 (80%)	3 (7%)	5 (13%)
Sudden Onset (n=111)	90 (81%)		21 (19%)

Case characteristics

A slight majority, 126/243(52%) of deaths were male. The age range of cases was between 2 and 70 years of age with a mean (\pm 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 GP 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.

Socio-economic status

One hundred and fifty-seven (65%) of cases lived in areas classified as disadvantaged. The mean (\pm 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, sixty-seven percent (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%) of cases. These factors included living alone, social disengagement and mental health issues. Mental illnesses included bi-polar 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, methamphetamines, methadone, cannabis and alcohol (see table 4). Sixty (25%) case records identified the deceased as a smoker.

Table 4: Toxicology results

Drug	n	Mean concentration ± Std Deviation
Alcohol - Blood ethanol	32	0.09 ± 0.09mg/L#
Opiates/Morphine/Pethidine	8	6±7mg/L+
Methadone	7	0.8±0.3mg/L
Amphetamine*	7	0.15±0.15mg/L
Cannabis ^	15	3±4.9mg/L
Ketamine	3	0.1, 0.7, 2.0mg/L
Caffeine	1	10mg/L

*Amphetamine and/or methamphetamine

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3 ^ Tetrahydrocannabinol
4 # By law blood ethanol <0.05g/100mL
5 + Therapeutic level Morphine 0.01-0.1, Pethidine 0.1-0.8
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7 Toxicology examination was performed in 159 cases, 84 of these reports were accessible.
8 Toxicology reports were not available for the 26 West Australian cases or 49 cases in other states.
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10 **Inadequate treatment/management**

11 Preventer medication ownership was recorded in 28% of cases. As information on asthma
12 medicines was not routinely recorded, conclusions on under-or-overuse of therapy or
13 financial barriers cannot be drawn. References to reliever/rescue medication use included
14 ownership of a symptom modifier without an accompanying preventer, evidence of expired
15 or empty rescue medication, inhalers/nebules strewn about the room and nebulizer machines
16 still running.
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27 Inadequate treatment was recorded in 43(18%) cases. Inadequate treatment was not only
28 related to poor self-management, but also included deficits in the provision of asthma care. It
29 was not possible, in most cases, to determine written action plan ownership from this data set.
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31 Unfamiliarity with the individual's asthma or inexperience with provision of asthma care by
32 both health professionals and carers was a contributing factor to several deaths that occurred
33 in the hospital, home and institutional settings.
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42 **Physical barriers**

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

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3 In 73(30%) cases, the deceased person was found after death. Sixty-three (26%) deceased
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5 persons were deemed to have delayed seeking assistance for their fatal asthma attack. In
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7 some cases, the failure to identify the seriousness of the asthma exacerbation was linked to
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9 drug and/or alcohol use. In some instances the deceased was reported to have curled up on
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11 the couch or gone to bed feeling unwell and was later found dead. In the case of those who
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13 lived alone and were found dead, the deceased was discovered by a friend or relative or by
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15 police conducting a welfare check after referral from a concerned person.
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20 21 **Respiratory tract infections**

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23 In 39 (16%) cases a respiratory tract infection was reported as present prior to the fatal
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25 asthma attack. Death certificate information between 2003 and 2007 gave an acute
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27 respiratory infection as a co-morbidity in 30% of deaths², therefore our figure is likely an
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29 underestimate. Seventy-seven (32%) cases of asthma death occurred in autumn and 63(26%)
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31 in winter.
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36 37 **Sudden onset death/ allergy/ anaphylaxis**

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39 Fatal asthma attacks were categorised as sudden onset in 111 (46%) cases rather than a
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41 gradual deterioration, which has significance in that it may limit the time available to
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43 effectively respond. Specific exposures prior to onset were identified in 22(9%) of cases and
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45 included food, non-steroidal anti-inflammatory or β -blocker medication, exposure to smoke
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47 or fumes and exercise. Between 2005and 2009, 27 deaths reported to the coroner were
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49 attributed to anaphylaxis. Although in 9 of these cases there was also a known history of
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51 asthma and allergy, as the death was coded as anaphylaxis, none of these 27 cases were
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53 included in this study.
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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 post-mortem information and toxicology reports, to confirm that 243/283 (86%) deaths were due to asthma rather than having asthma as a co-morbidity 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^{3,4,5,6} our findings provide a greater understanding of the current circumstances surrounding asthma deaths. Previous research identified inadequate assessment or therapy, delay in seeking help,^{3,4} smoking, alcohol abuse, family problems,⁵ and psychiatric disorders as factors in asthma deaths.⁶ 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 Australian population live in rural or remote areas and asthma prevalence is higher in inner city areas.¹¹ Previous population based research has reported on the relationship between mortality rates and remoteness of residence between 2003-2007.² In Australia, 'Medicare' a universal Government operated public health care 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 health care services physical distance and poor access to health services were clearly a factor in some cases that were examined, due to nature of our data set, however, we are unable to generalise about these findings.

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5 The conditions in which people live and work can lead to inequities in power and resources
6 and consequently to health inequalities.¹² Although socio-economic status and geographic
7 location, have previously been related to increased risks of death from asthma^{13,14} our study
8 confirms higher rates of asthma deaths among those living in areas of disadvantage², not in
9 the workforce and/or living in rural or remote areas, and among those with psychosocial
10 issues. Two-thirds of the asthma deaths we investigated occurred in people from
11 disadvantaged areas.
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23 Drug and alcohol use and smoking were very high in cases of asthma death compared with
24 the general population during the period of our investigation. A third of cases examined used
25 alcohol or illicit drugs prior to death compared to 9% and 13% respectively in the general
26 population over 14 years of age at this same time. Similarly, smoking rates were 25%
27 compared with 17%. Not all toxicology reports were available for examination electronically
28 and therefore actual drug and alcohol usage may be higher.
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38 According to information in police reports and coroners findings, the concentrations of drugs
39 observed in asthma deaths were not all at toxic levels. The average blood alcohol level of
40 0.09 mg/L is below toxic levels.¹⁵ However, the average opiate level including morphine,
41 pethidine and methadone in the group we studied, are all in excess of known toxic levels¹⁵,
42 indicating association of these drugs with death. It is likely that drug use, especially opiate
43 use, to toxic levels, is responsible for a failure to recognize worsening asthma and not
44 perceiving the risk of delay in seeking treatment. Given the known pharmacologic effects of
45 these drugs on histamine release, it is possible that narcotic use is particularly problematic in
46 the presence of asthma and physicians prescribing these drugs should be aware of this.
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3 Previous research undertaken in the United States (US) also identified illicit drug use as a
4 significant factor in cases of asthma deaths under 50 years of age and implied that the
5 increase in asthma deaths in the US may be a reflection of substance abuse and ethanol
6 consumption.¹⁶ Our data confirm these findings.
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14 A study investigating the involvement of β_2 -agonists and asthma deaths also reported the
15 presence in blood of ethanol, benzodiazepines, anti-depressants or antipsychotic medications,
16 morphine, diazepam, codeine, methadone as well as illicit substances such as amphetamine,
17 methamphetamine and cannabis.¹⁷ The author concluded that although alcohol probably does
18 not precipitate asthma, sulphites present in some forms of alcohol may trigger asthma in
19 susceptible patients. Furthermore the use of morphine was contraindicated in conditions such
20 as acute bronchial asthma as it may produce respiratory depression resulting in increased
21 $p_a\text{CO}_2$.¹⁷
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34 Our study identified a sub-set of apparently sudden onset asthma with rapid deterioration to
35 death. Kolbe *et al*, has previously reported that there appears to be a small proportion of
36 people with rapid onset severe asthma who do not demonstrate usual risk factors associated
37 with life threatening asthma and who require different management strategies.¹⁸ The eleven
38 deaths that occurred in public places were consistent with rapid-onset asthma attacks.
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45 Research has revealed that slow onset asthma attacks of near fatal asthma and rapid onset
46 attacks may have different trigger factors, with allergens a likely trigger in rapid onset and
47 infection in slow onset attacks.^{19,20} James *et al*, have also reported on the dichotomy of time
48 to death and the eosinophil/neutrophil ratio in cases of asthma and of the presence of muscle
49 shortening in short course cases (< 3 hours) and accumulation of mucus in long course cases
50 (>8 hours).²¹ Mode of onset and mechanism to death vary with asthma and thus medical
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3 interventions, both acute and long term as well as more global strategies to minimise risk will
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5 need to allow for this variation.
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10 Several deaths were likely due to acute hypersensitivity reactions including beta-blocker eye
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12 drops and non-steroidal anti-inflammatory treatments. Our findings should alert practitioners
13
14 to the possible adverse consequences of prescribing these agents in asthma and highlight the
15
16 importance of an asthma action plan to advise patients to act in the event of asthma
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18 worsening.
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23 Respiratory viral infections, recognised as the most important causes of asthma exacerbations
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25 in both children and adults, emergency department attendances^{22,23} and hospitalisation
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27 admissions in older people during winter² were a precursor to many fatal asthma
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29 exacerbations, but often not perceived as a risk or reason to seek asthma care. Previous
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31 research by our team that demonstrated differing perceptions of ‘what constitutes an asthma
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33 attack’ also added evidence that for many people despite preventive therapy use, a respiratory
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35 viral infection, may result in an asthma episode that they are ‘unable to control’.^{24,22} A recent
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37 study evaluating the effect of different asthma treatments on common cold-related asthma
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39 exacerbations found severe exacerbations were reduced by budesonide / formoterol
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41 maintenance therapy and emphasised the role of inhaled corticosteroids.²⁵
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47 Un-familiarity with the individual and their particular asthma needs was a factor that led to
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49 inadequate treatment by health professionals and carers in the hospital, the home and the
50
51 institutions. This demonstrated the importance of not only continuity of care, but tailored care.
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53 In the case of children this may require parents and/or carers taking on a more assertive role.
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3 Ownership of written action plans has declined, despite their being protective against asthma
4 death⁵ and research reporting ownership as useful.²³ In 2007-2008 less than 20% of the
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7 population with asthma were reported to own one.² Education, especially if delivered with a
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10 written asthma action plan, will assist in the recognition of asthma exacerbations, appropriate
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12 emergency asthma management and seeking care in a timely fashion. The delivery of home-
13
14 based person-centred asthma self-management education utilising the recently developed
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16 Patient Asthma Concerns Tool (PACT) has also proven successful in those over 50 year of
17
18 age.²⁶ Although evidence of written action plan ownership and asthma self-management
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20 education was available in some cases, unfortunately this information was not available for
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23 most.

24 25 26 27 *Study limitations*

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29 Our retrospective study differs to the previous mortality studies in that we used the NCIS to
30
31 identify asthma deaths. Limitations of our data include the examination of only those asthma
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33 deaths that were reported to the Coroner. Cases where a Medical Practitioner was willing to
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35 complete and sign the death certificate certifying the asthma death was not 'unexpected'
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37 'unnatural' or 'someone in care at the time of death' were not known to us. Thus cases are
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39 likely to be biased toward younger people or those institutionalised at the time of death.
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41 Anticipated deaths from asthma would not have been reported and as a consequence our
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43 study may under-estimate this group. As cause of death analysis focuses on only one
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45 underlying cause rather than multiple causes of death, the overall contribution of asthma to
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47 adult deaths in Australia is also likely to be underestimated as was found in England.²⁷
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54 **Conclusion**

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56 Our retrospective study provides a current assessment of 'reportable' asthma deaths across
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3 Australia. Seventy percent of these deaths were considered preventable and our findings
4 suggest that to achieve further reductions in the rate of asthma deaths in Australia, among
5 those aged under 70 years of age, multi-faceted interventions targeted at the personal,
6 practice and policy levels will be required.
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14 At the personal level, improvement in the asthma health literacy among those with infrequent
15 asthma is required to identify and manage worsening symptoms, and the risks associated with
16 delay in seeking care. Parents and carers should also develop confidence to manage an attack,
17 implement an emergency plan and to recognise when it is appropriate for them to take control
18 if the person experiencing an asthma exacerbation fails to do so. The delivery of home-based
19 self-management education could be appropriate to reach those who are frail, house-bound
20 and/or socially isolated. E-health technologies should also be considered as a means for
21 delivering education and advice for those living in areas where geographical distance is
22 problematic.
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36 Health professionals working in primary care settings need to ensure all patients, not just
37 those with moderate to severe asthma, receive comprehensive asthma education, a written
38 Asthma Action Plan and advice about the potential risk of delay in seeking care. Quality
39 Awards system, such as those operating in the UK, could be introduced to encourage delivery
40 of guideline based asthma care in Australian practices.²⁸
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50 At the policy level, current asthma guidelines need to highlight issues associated with asthma
51 management in those with psycho-social problems, including drug and alcohol addiction
52 given that both are problematic and widespread. Provision of asthma education and a written
53 asthma action plan should also be mandatory to those who present to emergency departments.
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5 Interventions that specifically target community needs are also required. Reforms are needed
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7 to address inequity in health care delivery to 'reach the un-reached' as well as raising
8
9 awareness of dangers associated with smoking, drug and alcohol use and the consequences of
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11 delay in seeking care for those with asthma. A recent method of engaging communities has
12
13 been the use of performance²⁹ to raise awareness and deliver health messages. These plays
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15 can be performed in a variety of settings, including schools, pubs, seniors clubs and
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17 conferences. The recently introduced Medicare Local network in Australia is likely a place to
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19 determine a need.
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25 **Future research**

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27 Future research into asthma mortality in Australia should consider a prospective 12 month
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29 national review of all asthma deaths. The review should investigate asthma deaths across all
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31 age groups, the circumstances surrounding the death as well as the management of fatal
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33 attacks and the quality of care in the preceding 12 months such as that currently being
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35 undertaken in the United Kingdom.³⁰
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49
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51
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53
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55
56 South Australian Coroner's Office for their assistance accessing case data.
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CONTRIBUTORSHIP STATEMENT

DG & JD conceived the idea of the study and DG, JD and MA were responsible for the design of the study. DG, EM, JD, CZ and MA were responsible for undertaking for the data analysis, and 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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COMPETING INTERESTS

None

DATA SHARING

No additional data available

FIGURE LEGENDS

Fig 1: Flow diagram of cases examined

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Asthma Mortality in Australia in the 21st Century: a case series analysis

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Keywords: Asthma mortality, self-management, health-literacy, access to healthcare, psychosocial issues.

(word count 3637)

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 reasons for asthma deaths between 2005 and 2009.

Design

We undertook a case series analysis by searching the National Coroners' Information System (NCIS) using the most recent International Classification of Diseases (ICD-10) codes J45 & 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? Due to the likelihood of co-morbidities or alternative diagnoses contributing to deaths in those over 70 years of age, this group was excluded.

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.

Conclusion

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 health care delivery to 'reach the un-reached'. 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.

(286 words)

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 remains 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 un-reached’ by targeting practice and policy in addition to interventions at a personal level to improve asthma related health literacy.

Strengths and limitations

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 confirmed that 243/283 deaths were due to asthma rather than having asthma as a co-morbidity when another immediate cause of death existed. We identified preventable or modifiable factors in 70% of these deaths.

Recently introduced privacy laws prevent use of death registries in Australia for the purpose of identifying individuals who have died. Our study therefore differs to the previous mortality studies in that we used the NCIS to identify asthma deaths. Limitations of our data include

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3 the examination of only those asthma deaths that were reported to the Coroner. The Coroner
4 investigates 'reportable' deaths that is, a death that is 'unexpected' 'unnatural', 'violent' or
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6 the death of those 'in care' at the time of death. Thus cases are likely to be biased toward
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8 younger people or those institutionalised at the time of death. Anticipated deaths from
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10 asthma would not have been reported and as a consequence our study may under-estimate
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12 this group. As cause of death analysis focuses on only one underlying cause rather than
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14 multiple causes of death, the overall contribution of asthma to adult deaths in Australia is also
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16 likely to be underestimated.
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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

Previous asthma mortality studies were undertaken in Victoria and South Australia during the late 1980s and the 1990s.^{3,4,5,6} As the pattern of asthma deaths may have changed over the last decade and more effective medications are now available, we undertook a study of deaths between 2005 and 2009 to discover the current circumstances surrounding the deaths and to identify potential interventions.

METHODS

Data collection

As recently introduced privacy laws prevent use of Death registries in Australia for the purpose of identifying individuals who 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'.

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3 At the conclusion of every investigation, it is the task of the Coroner to prepare a written
4 finding to establish wherever possible: the identity of the deceased; the circumstances
5 surrounding the death; the cause of death; and the particulars needed to register the death. An
6 autopsy, undertaken by a forensic pathologist, can help explain the cause of death and is part
7 of the coronial investigation into 'reportable' deaths. As the next of kin has a legal right to
8 file an objection to an autopsy being conducted the Coroner will take into consideration any
9 such objection and therefore an autopsy is not always carried out. Once the pathologist has all
10 the results of the tests, a detailed report is prepared for the Coroner, which outlines medical
11 findings and conclusions. The Coroner takes this information into account when making a
12 finding. Once the Coroner has made a finding, the case is considered "closed" and coded
13 according to International Classification of Disease for the underlying cause of death.
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29 We ascertained the number of asthma deaths recorded in each state and territory in Australia,
30 between 2005 and 2009, using available Australian Bureau of Statistics¹ and Australian
31 Institute of Health and Welfare (AIHW) data (see tables 1 & 2).⁷
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38 We then undertook a retrospective case series analysis by searching the National Coroners'
39 Information System (NCIS)⁸ using the most recent International Classification of Diseases
40 (ICD-10) codes J45 & J46⁹ and the keyword 'asthma' as the underlying cause of death.
41 Coroner's findings, autopsy, toxicology and police reports were reviewed to determine: if the
42 team agreed the death was due to asthma and whether the death was preventable or
43 modifiable factors existed? Cases of asthma deaths in those under 70 years of age that were
44 deemed to be due to asthma were included in our analysis. The team consisted of three
45 respiratory physicians, a medical sociologist and a research officer.
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3 Demographic, co-morbidities, medication use and smoking history information were noted
4 from available police, toxicology, autopsy reports or Coroner's findings. Preventable deaths
5 were assessed on the basis of available details, and consensus clinical judgement if different
6 or specific actions had been taken and the death was likely to have been avoided. Modifiable
7 factors associated with the death were factors amendable to change and that may have
8 contributed to the fatal outcome.
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18 **Data analysis**

19 *Socio-economic status*

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21 Socio-economic status (SES) was determined using ABS-Socio Economic Indices For Areas
22 (SEIFA) a continuum of advantage (high values) to disadvantage (low values). SEIFA used a
23 broad definition of relative socio-economic disadvantage in terms of people's access to
24 material and social resources, and their ability to participate in society.
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26 Advantage/disadvantage classifications were derived from Census variables related to low
27 income, low educational attainment, unemployment, dwellings without motor vehicles, high
28 household income and tertiary education.¹⁰ SEIFA index scores were standardised to a mean
29 of 1000. A lower score indicated an area of relative disadvantage compared to an area with a
30 score higher than 1000
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45 *Exclusion criteria*

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47 Due to the likelihood of co-morbidities or alternative diagnoses contributing to deaths in
48 those over 70 years of age, this group was excluded.
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54 *Statistical analysis*

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56 Descriptive analysis was performed using SPSS version 20 (Statistical Package for Social
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Sciences, IBM Corporation 2011). Chi-square was used to test differences of proportions.

Ethics

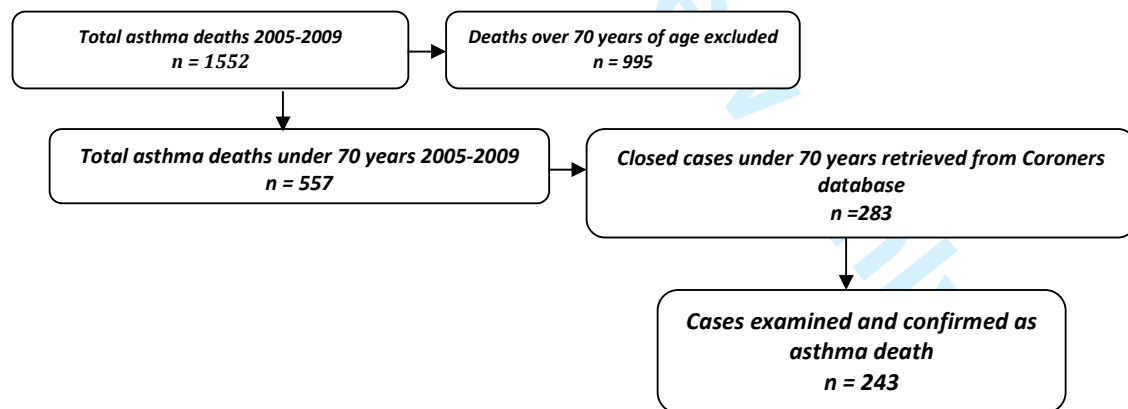
The Alfred Hospital Human Research and the Department of Justice Ethics Committees approved the study.

RESULTS

Data

The Justice Department granted permission to access data for closed cases, **that is cases where the Coroner had made a finding**, across Australia. West Australian data (26 cases) were restricted to non-identifying demographic information. Of 557 asthma deaths in those under 70 years of age between 2005 and 2009, we retrieved 283(51%) cases (see fig 1).

Fig 1: Flow diagram of cases examined



Sufficient information was available (Coroners findings, autopsy, toxicology and police reports) to determine the main cause of death as asthma in 243 of the 283 cases. An autopsy had been conducted in 209(86%) cases and toxicological analysis in 159(56%) cases (84/159

were accessible on the NCIS). Tables 1 and 2 provide a breakdown of the overall death rate, age, gender and SEIFA classification of the cases examined.

Table 1: Asthma deaths/rate per 100,000 in Australia by age from 2005 to 2009

Age	2005	2006	2007	2008	Overall
0-9	3	0	1	7	11
10-19	4	5	4	4	17
20-29	14	11	16	9	50
30-39	11	8	15	23	57
40-49	34	22	24	25	105
50-59	22	27	32	36	117
60-69	39	56	52	53	200
Total under 70 years	127	129	144	157	557
70-79	47	68	53	61	229
80-89	144	205	188	229	766
Total 70 years & over	191	273	241	290	995
Overall deaths and rate per 100,000/year	318 (1.5)	402(1.8)	385 (1.7)	449 (1.9)	1552

Source: Australian Bureau of Statistics. Causes of Death 2010.

Table 2: Cases deemed to be asthma deaths examined from NCIS between 2005 and 2009 by age, gender and Socioeconomic Index For Areas (SEIFA)

	2005	2006	2007	2008	Overall
Age					
0-9	2	0	1	6	9
10-19	3	3	2	4	12
20-29	9	8	12	2	31
30-39	8	5	9	13	35
40-49	20	13	11	10	54
50-59	12	18	8	15	53
60-69	16	11	12	9	48
Total under 70	70	58	56	59	243
Gender					
Male	39	25	28	34	126
Female	31	33	28	25	117
Total	70	58	56	59	243
SEIFA					
-1000	18% (45)	14% (33)	16% (38)	17% (41)	65% (157)
+1000	10% (24)	10% (25)	7% (18)	7% (18)	35% (85)
Missing	1				
Total	70	58	56	59	243

Preventable / modifiable deaths

Preventable or have 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.

Table 3: Characteristics of preventable / modifiable deaths

	Preventable or Modifiable factors (n=169)	Non-preventable or modifiable factors (n=4)	Insufficient data to determine if death was preventable (n = 70)
Age	43 ± 17	57 ± 10	46 ± 17
Gender	90M 79F	2M 2F	34M 36F
SEIFA	985 ± 74	980 ± 98	968 ± 70
Location of death			
Home/friends (n=145)	122 (84%)	4 (3%)	19 (13%)
Hospital/GP (n=20)	14 (70%)	0	6 (30%)
Ambulance/on way to hospital (n=13)	12 (92%)	0	1 (8%)
Public place (n=11)	11 (100%)	0	0
Residential care (n=6)	3 (50%)	0	3 (50%)
Missing (n=47)	8 (17%)	0	39 (83%)
Psychosocial issues (n=106)	93 (88%)	2 (2%)	11 (10%)
Drug & Alcohol abuse (n = 83)	78 (85%)	1 (1%)	4 (4%)
Delay in seeking help (n =63)	57 (89%)		6 (9%)
Respiratory Tract Infection (n =39)	31 (80%)	3 (7%)	5 (13%)
Sudden Onset (n=111)	90 (81%)		21 (19%)

Case characteristics

A slight majority, 126/243(52%) of 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

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2
3 caravan. Twenty (8%) deaths occurred either at a hospital or GP Clinic, and 13(4%) on the
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5 way to hospital. Eleven deaths (4%) occurred in public places (airport, school, bus stop,
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7 restaurant, street, workplace, camping ground). Six deaths (2%) occurred in residential
8
9 institutions. The location of death was not available for 47(19%) cases.
10
11

12 13 14 **Socio-economic status**

15
16 One hundred and fifty-seven (65%) of cases lived in areas classified as disadvantaged. The
17
18 mean (\pm SD) SEIFA advantage/disadvantage classification of cases was 980 ± 74 . Of the
19
20 169 preventable or modifiable deaths, 106(62%) were classified as disadvantaged. A slightly
21
22 higher number of preventable deaths, sixty-seven percent (106/157), occurred in those living
23
24 in disadvantaged areas.
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26

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28
29 Only 91(37%) of the deceased persons were employed at the time of death. Seventeen (7%)
30
31 were women undertaking home duties, 61(25%) were unemployed, 29(12%) were retired,
32
33 19(8%) were students and 2(1%) were children under 5 years of age. There was no
34
35 employment status listed for 24(10%) cases.
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39 40 41 **Psychosocial issues**

42
43 Psychosocial factors were identified in 106(49%) of cases. These factors included living
44
45 alone, social disengagement and mental health issues. Mental illnesses included bi-polar
46
47 disorder, depression, schizophrenia, personality or compulsive obsessive disorders and
48
49 anxiety.
50
51

52 53 54 **Drug and alcohol use/abuse**

55
56 Drug and alcohol abuse was identified as a factor contributing to death in 83(34%) cases.
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Recreational/illicit drugs included opiates, methamphetamines, methadone, cannabis and alcohol (see table 4). Sixty (25%) case records identified the deceased as a smoker.

Table 4: Toxicology results

Drug	n	Mean concentration ± Std Deviation
Alcohol - Blood ethanol	32	0.09 ± 0.09mg/L#
Opiates/Morphine/Pethidine	8	6±7mg/L+
Methadone	7	0.8±0.3mg/L
Amphetamine*	7	0.15±0.15mg/L
Cannabis ^	15	3±4.9mg/L
Ketamine	3	0.1, 0.7, 2.0mg/L
Caffeine	1	10mg/L

*Amphetamine and/or methamphetamine

^ Tetrahydrocannabinol

By law blood ethanol <0.05g/100mL

+ Therapeutic level Morphine 0.01-0.1, Pethidine 0.1-0.8

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.

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 nebulizer 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 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 inexperience 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%) of 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 as present prior to the fatal asthma attack. Death certificate information between 2003 and 2007 gave an acute respiratory infection as a co-morbidity in 30% of deaths², therefore our figure is 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

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3 gradual deterioration, which has significance in that it may limit the time available to
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5 effectively respond. Specific exposures prior to onset were identified in 22(9%) of cases and
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7 included food, non-steroidal anti-inflammatory or β -blocker medication, exposure to smoke
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9 or fumes and exercise. Between 2005 and 2009, 27 deaths reported to the coroner were
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11 attributed to anaphylaxis. Although in 9 of these cases there was also a known history of
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13 asthma and allergy, as the death was coded as anaphylaxis, none of these 27 cases were
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15 included in this study.
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20 21 **DISCUSSION**

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23 Our retrospective study of asthma deaths between 2005 and 2009 is the most recent study of
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25 asthma deaths undertaken in Australia for nearly two decades, and the first to report asthma
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27 deaths across Australia. We revealed high specificity in the recording of asthma deaths,
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29 during examination of post-mortem information and toxicology reports, to confirm that
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31 243/283 (86%) deaths were due to asthma rather than having asthma as a co-morbidity when
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33 another immediate cause of death existed. We considered that 70% of these deaths had
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35 preventable or modifiable factors.
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41 Although there are similarities between our findings and preventable or modifiable factors
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43 reported in earlier studies^{3,4,5,6} our findings provide a greater understanding of the current
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45 circumstances surrounding asthma deaths. Previous research identified inadequate assessment
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47 or therapy, delay in seeking help,^{3,4} smoking, alcohol abuse, family problems,⁵ and
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49 psychiatric disorders as factors in asthma deaths.⁶ In addition to these factors, our findings
50
51 identify disadvantage as an underlying theme among asthma deaths in Australia and a link
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53 between inequity, psychosocial issues, health literacy and social isolation. A further concern
54
55 is the higher rate of asthma deaths among those residing in rural or remote areas (45%) given
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3 that only 32% of the overall Australian population live in rural or remote areas and **asthma**
4 **prevalence is higher in inner city areas.**¹¹ Previous population based research has reported on
5 **the relationship between mortality rates and remoteness of residence between 2003-2007.**² In
6 **Australia, 'Medicare' a universal Government operated public health care system provides**
7 **free or subsidised treatment by Doctors and Specialists and free treatment as a public patient**
8 **in a public hospital. Despite this equity of access to health care services physical distance**
9 **and poor access to health services were clearly a factor in some cases that were examined,**
10 **due to nature of our data set, however, we are unable to generalise about these findings.**
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23 The conditions in which people live and work can lead to inequities in power and resources
24 and consequently to health inequalities.¹² Although socio-economic status and geographic
25 location, have previously been related to increased risks of death from asthma^{13,14} our study
26 confirms higher rates of asthma deaths among those living in areas of disadvantage², not in
27 the workforce and/or living in rural or remote areas, and among those with psychosocial
28 issues. Two-thirds of the asthma deaths we investigated occurred in people from
29 disadvantaged areas.
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41 Drug and alcohol use and smoking were very high in cases of asthma death compared with
42 the general population during the period of our investigation. A third of cases examined used
43 alcohol or illicit drugs prior to death compared to 9% and 13% respectively in the general
44 population over 14 years of age at this same time. Similarly, smoking rates were 25%
45 compared with 17%. Not all toxicology reports were available for examination **electronically**
46 and therefore actual drug and alcohol usage may be higher.
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56 According to information in police reports and coroners findings, the concentrations of drugs
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3 observed in asthma deaths were not all at toxic levels. The average blood alcohol level of
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5 0.09 mg/L is below toxic levels.¹⁵ However, the average opiate level including morphine,
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7 pethidine and methadone in the group we studied, are all in excess of known toxic levels¹⁵,
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9 indicating association of these drugs with death. It is likely that drug use, especially opiate
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11 use, to toxic levels, is responsible for a failure to recognize worsening asthma and not
12
13 perceiving the risk of delay in seeking treatment. Given the known pharmacologic effects of
14
15 these drugs on histamine release, it is possible that narcotic use is particularly problematic in
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17 the presence of asthma and physicians prescribing these drugs should be aware of this.
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20 Previous research undertaken in the United States (US) also identified illicit drug use as a
21
22 significant factor in cases of asthma deaths under 50 years of age and implied that the
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24 increase in asthma deaths in the US may be a reflection of substance abuse and ethanol
25
26 consumption.¹⁶ Our data confirm these findings.
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32 A study investigating the involvement of β_2 -agonists and asthma deaths also reported the
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34 presence in blood of ethanol, benzodiazepines, anti-depressants or antipsychotic medications,
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36 morphine, diazepam, codeine, methadone as well as illicit substances such as amphetamine,
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38 methamphetamine and cannabis.¹⁷ The author concluded that although alcohol probably does
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40 not precipitate asthma, sulphites present in some forms of alcohol may trigger asthma in
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42 susceptible patients. Furthermore the use of morphine was contraindicated in conditions such
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44 as acute bronchial asthma as it may produce respiratory depression resulting in increased
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46 $p_a\text{CO}_2$.¹⁷
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52 Our study identified a sub-set of apparently sudden onset asthma with rapid deterioration to
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54 death. Kolbe *et al*, has previously reported that there appears to be a small proportion of
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56 people with rapid onset severe asthma who do not demonstrate usual risk factors associated
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3 with life threatening asthma and who require different management strategies.¹⁸ The eleven
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5 deaths that occurred in public places were consistent with rapid-onset asthma attacks.
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8 Research has revealed that slow onset asthma attacks of near fatal asthma and rapid onset
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10 attacks may have different trigger factors, with allergens a likely trigger in rapid onset and
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12 infection in slow onset attacks.^{19,20} James *et al*, have also reported on the dichotomy of time
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14 to death and the eosinophil/neutrophil ratio in cases of asthma and of the presence of muscle
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16 shortening in short course cases (< 3 hours) and accumulation of mucus in long course cases
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18 (>8 hours).²¹ Mode of onset and mechanism to death vary with asthma and thus medical
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20 interventions, both acute and long term as well as more global strategies to minimise risk will
21
22 need to allow for this variation.
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27 Several deaths were likely due to acute hypersensitivity reactions including beta-blocker eye
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29 drops and non-steroidal anti-inflammatory treatments. Our findings should alert practitioners
30
31 to the possible adverse consequences of prescribing these agents in asthma and highlight the
32
33 importance of an asthma action plan to advise patients to act in the event of asthma
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35 worsening.
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40 Respiratory viral infections, recognised as the most important causes of asthma exacerbations
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42 in both children and adults, emergency department attendances^{22,23} and hospitalisation
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44 admissions in older people during winter² were a precursor to many fatal asthma
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46 exacerbations, but often not perceived as a risk or reason to seek asthma care. Previous
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48 research by our team that demonstrated differing perceptions of ‘what constitutes an asthma
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50 attack’ also added evidence that for many people despite preventive therapy use, a respiratory
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52 viral infection, may result in an asthma episode that they are ‘unable to control’.^{24,22} A recent
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54 study evaluating the effect of different asthma treatments on common cold-related asthma
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3 exacerbations found severe exacerbations were reduced by budesonide / formoterol
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5 maintenance therapy and emphasised the role of inhaled corticosteroids.²⁵
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10 Un-familiarity with the individual and their particular asthma needs was a factor that led to
11
12 inadequate treatment by health professionals and carers in the hospital, the home and the
13
14 institutions. This demonstrated the importance of not only continuity of care, but tailored care.
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16 In the case of children this may require parents and/or carers taking on a more assertive role.
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21 Ownership of written action plans has declined, despite their being protective against asthma
22
23 death⁵ and research reporting ownership as useful.²³ In 2007-2008 less than 20% of the
24
25 population with asthma were reported to own one.² Education, especially if delivered with a
26
27 written asthma action plan, will assist in the recognition of asthma exacerbations, appropriate
28
29 emergency asthma management and seeking care in a timely fashion. The delivery of home-
30
31 based person-centred asthma self-management education utilising the recently developed
32
33 Patient Asthma Concerns Tool (PACT) has also proven successful in those over 50 year of
34
35 age.²⁶ **Although evidence of written action plan ownership and asthma self-management**
36
37 **education was available in some cases, unfortunately this information was not available for**
38
39 **most.**
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45 *Study limitations*

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47 Our **retrospective** study differs to the previous mortality studies in that we used the NCIS to
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49 identify asthma deaths. Limitations of our data include the examination of only those asthma
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51 deaths that were reported to the Coroner. Cases where a Medical Practitioner was willing to
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53 complete and sign the death certificate certifying the asthma death was not 'unexpected'
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55 'unnatural' or 'someone in care at the time of death' were not known to us. Thus cases are
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likely to be biased toward younger people or those institutionalised at the time of death. Anticipated deaths from asthma would not have been reported and as a consequence our study may under-estimate this group. As cause of death analysis focuses on only one underlying cause rather than multiple causes of death, the overall contribution of asthma to adult deaths in Australia is also likely to be underestimated as was found in England.²⁷

Conclusion

Our retrospective study provides a current assessment of 'reportable' asthma deaths across Australia. Seventy percent 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, multi-faceted interventions targeted at the personal, practice and policy levels will be required.

At the personal level, improvement in the 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 for delivering education and advice for those living in areas where geographical distance is problematic.

Health professionals working in primary care settings need to ensure all patients, not just those with moderate to severe asthma, receive comprehensive asthma education, a written

1
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3 Asthma Action Plan and advice about the potential risk of delay in seeking care. Quality
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5 Awards system, such as those operating in the UK, could be introduced to encourage delivery
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7 of guideline based asthma care in Australian practices.²⁸
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12 At the policy level, current asthma guidelines need to highlight issues associated with asthma
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14 management in those with psycho-social problems, including drug and alcohol addiction
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16 given that both are problematic and widespread. Provision of asthma education and a written
17
18 asthma action plan should also be mandatory to those who present to emergency departments.
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23 Interventions that specifically target community needs are also required. Reforms are needed
24
25 to address inequity in health care delivery to 'reach the un-reached' as well as raising
26
27 awareness of dangers associated with smoking, drug and alcohol use and the consequences of
28
29 delay in seeking care for those with asthma. A recent method of engaging communities has
30
31 been the use of performance²⁹ to raise awareness and deliver health messages. These plays
32
33 can be performed in a variety of settings, including schools, pubs, seniors clubs and
34
35 conferences. The recently introduced Medicare Local network in Australia is likely a place to
36
37 determine a need.
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40 41 42 43 **Future research**

44
45 Future research into asthma mortality in Australia should consider a prospective 12 month
46
47 national review of all asthma deaths. The review should investigate asthma deaths across all
48
49 age groups, the circumstances surrounding the death as well as the management of fatal
50
51 attacks and the quality of care in the preceding 12 months such as that currently being
52
53 undertaken in the United Kingdom.³⁰
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CONTRIBUTORSHIP STATEMENT

DG & JD conceived the idea of the study and DG, JD and MA were responsible for the design of the study. DG, EM, JD, CZ and MA were responsible for undertaking for the data analysis, and 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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