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## Dynamic pattern of suicide in Australia, 1986–2005

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# Dynamic pattern of suicide in Australia, 1986–2005

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## ABSTRACT

**Objective:** Patterns of suicide have been studied in many countries, but little has done in integrating different patterns of suicide over time and across local areas in Australia. This study explored the spatiotemporal variations of suicide across Australia from 1986 to 2005, discussed the reasons for dynamic changes and recommended future suicide research and prevention strategies.

**Design:** Suicide (1986–2005) and population data were obtained from the Australian Bureau of Statistics. A series of analyses were conducted to examine the suicide pattern by sex, method and age group over time and space.

**Results:** Apparent differences in suicide rates across sex, age groups and suicide methods were found across different geographical areas. Male suicides were mainly completed by hanging, firearms, gases and poison. Female suicides were primarily completed by hanging and poison. Male rate was high in rural areas while female rate was high in capital cities. Suicide rate by firearms was higher in rural areas than urban areas, while the pattern for poison was opposite. Suicide rates slightly fluctuated for total population and aged between 15 and 54, while suicide decreased among 55 years and over during the study period. There was a decrease of suicide by firearms during the study period especially after 1996 when new firearm control law was implemented; while suicide by hanging kept increasing. The change of suicide patterns by hanging and firearms was more significant in males, Northern Territory and South Australia, and some rural and remote areas in other states.

**Conclusions:** Suicide rates varied over time and space and across sexes, age groups, suicide methods. Suicide control and prevention strategies should target particular groups and areas of high and increased risk (e.g., Indigenous communities).

**Key words:** suicide, Australia, pattern

## STRENGTHS AND LIMITATIONS OF THE STUDY

This study used various cross-tabs with the 20-year Australian national suicide data cut in different ways (e.g., population group, suicide methods, time and space), and provides valuable information for examining suicide trends in Australia.

The different suicide rates across population groups and by suicide methods were presented, which may help in designing effective suicide control and prevention programs. Different levels of spatial scales (LGA and SLA) were combined to best display the spatial distribution of suicide patterns; and the boundary changes over years were also adjusted using advanced GIS methods.

This study only examined the suicide pattern at the population level using aggregated data. Detailed individual information such as marriage, employment, Indigenous status and health status before suicide was not available in the current dataset. Thus ecological fallacy is inevitable in this study and the results are difficult to be interpreted at the individual level.

The quality of suicide data may influence the results of the study. There is evidence suggesting that some suicide deaths were not covered in the current ABS database. The real suicide rate may be underestimated so the results should be interpreted with caution.

The suicide database was acquired a few years ago and may not indicate the trend of suicide after 2005.

## INTRODUCTION

Suicide has long been regarded as a major public health issues globally, with about 1 million suicide deaths annually.<sup>1</sup> Suicide patterns, including suicide methods, time and geographical variation have been explored in many countries and regions, such as China,<sup>2</sup> India,<sup>3</sup> Russia<sup>4</sup> and United States.<sup>5</sup> In Australia, suicide rates have fluctuated since the early 20<sup>th</sup> century, but

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3 have remained below 10 per 100,000 in recent years.<sup>1 6</sup> However, there were still around  
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5 2,000 suicide deaths annually, mainly in young males. Thus, it is vital to understand the  
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7 variations of suicide patterns over time, space, population groups (age, sex and ethnic groups)  
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9 and the possible reasons for these variations, in order to design effective suicide control and  
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11 prevention programs. Previous studies have explored suicide patterns in Australia over time,<sup>6-</sup>  
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13 <sup>8</sup> methods<sup>9</sup> and space.<sup>10</sup> To date, however, few studies have integrated the different patterns  
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15 of suicide over a long term trend and across small areas in one study and compared them. The  
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17 spatial patterns of suicide by different population groups and suicide methods over a long  
18  
19 term have not yet been examined. The trends of suicide rates over time may differ across  
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21 population groups (e.g., young or older adults) and areas (e.g., suicide by firearms in urban or  
22  
23 rural areas). Thus, this study examined long-term (both dynamic and static), spatiotemporal  
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25 patterns of Australian national suicide, using a range of different combinations of age, time,  
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27 method, and location from the period 1986-2005.  
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## 31 32 **DESIGN**

### 33 34 35 **Data source**

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38 The unit record data of suicide deaths between 1986 and 2005 were acquired from Australian  
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40 Bureau of Statistics (ABS), including sex, International Classification of Disease (ICD) Code  
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42 (ICD 9: 950.0-959.9; ICD 10: X60-X84)<sup>11 12</sup> relating to suicide or self-inflicted injury, age,  
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44 country of birth, date of suicide and Statistical Local Area (SLA) code. The application of  
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46 access to suicide database in more recent years is still under review by ABS. As SLA  
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48 boundaries have changed dramatically over the study period, especially in urban areas, we  
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50 chose Local Governmental Area (LGA) as the standard geographical unit to explore the  
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52 spatial pattern of suicide. Each LGA is composed of one or more SLAs and the LGA  
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54 boundaries are relatively stable over the study period. The Australian Standard Geographical  
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3 Classification (ASGC), updated annually, was used to incorporate SLA codes into LGA  
4 codes, examine and adjust for SLA/LGA boundary changes over time. CDATA 2001, a  
5 product issued by ABS, provided digital boundaries and socio-demographic data of Australia  
6 (including 1991, 1996 and 2001 population census data at SLA/LGA levels, based on 2001  
7 Census boundary) and was applied in MapInfo 10.5 software package for map display.<sup>13</sup>  
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9 Population data (SLA/LGA levels) in 1986 and 2006 Census from ABS were merged with  
10 2001 Census data after adjustment for boundary changes using ASGC references. The suicide  
11 rates in different groups over time and across LGAs were then calculated. In this study, we  
12 categorize LGAs as three types: metropolitan areas of capital cities, regional centres (other  
13 LGA named as “city” outside of capital cities, e.g., City of Townville), rural and remote areas  
14 (the remaining LGAs).  
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28 Most areas in South Australia (SA) and Northern Territory (NT) have a very low population  
29 density and were defined as unincorporated areas by ABS at the LGA level, but these areas  
30 were also composed of 27 SLAs according to the 2001 Census data. Thus we applied SLA  
31 data in unincorporated areas in SA and NT to provide more detailed information. In the 2001  
32 Census, Australia was divided into 628 LGAs, plus 27 SLAs in the unincorporated areas of  
33 SA and NT. Ethical approval was granted by the Human Research Ethics Committee,  
34 Queensland University of Technology.  
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#### 44 **Statistical analyses**

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47 Descriptive and mapping approaches were applied to explore the age, sex, method, time and  
48 regional-specific patterns of suicide cases and rates. Firstly, we explored the basic pattern of  
49 suicide among different groups by calculating suicide rates, relative risk (RR) and 95%  
50 Confident Interval (CI) to annual mean of national suicide rate over the study period. Then the  
51 temporal trends of suicide rates in population groups were examined, using yearly data and  
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Poisson regression. All the statistical analyses were implemented by SPSS 21.0.<sup>14</sup> Finally suicide rates at the LGA level were applied to display suicide rates over sexes, age groups and suicide methods using mapping approaches by MapInfo 10.5.<sup>13</sup> We used the annual average sex-specific rates for the whole of Australia over the entire study period as the reference to calculate age-adjusted standardised mortality ratio (SMR) of both sexes which were mapped.

## RESULTS

This study included 45,293 suicide deaths in 20 years and only 187 suicides aged below 15, about 0.4% of total suicides. Thus we did not specifically analyse the pattern of suicide below 15 years; however, we still keep them in results of all-age groups. Table 1 indicates that most of suicides occurred in those aged between 15 and 54 and occurred in capital cities and regional centres, as the majority of Australian population live in urban areas. However, suicide rate in rural and remote areas was higher than that in urban areas. Around 80% of suicides were males and most suicides aged between 15 and 54 years, while older males (75-year and over) had higher suicide rate than males in other age groups. Most suicides were in four methods: (1) firearms, air guns and other explosive (simplified as firearms); (2) hanging; (3) gases and vapours; (4) solid or liquid substances. The relative risk (RR) and 95% Confident Interval (CI) of suicide in each population group and by different methods were calculated, using annual average suicide incidence in the study period in Australia as a reference (Table 1). We also applied Chi square test to check the suicide cases distribution by population groups and methods, and all the results are significant.

Table 1 about here

Figure 1 shows the time-series trends of suicide by different groups. There was a peak of suicide rate among the total population from 1996 to 1998, particularly in males aged between 15 and 34 years (A), males in rural and remote areas (B) and suicide completed by hanging

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3 (C). In the early years of the study period, suicide incidence among 55 years and over was  
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5 higher than those below 55 years, however, it was observed to drop lower than that of young  
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7 and middle aged adults in recent years (A). The trends of suicide among 15 to 54 years had  
8  
9 slight fluctuations during the study period among different sub-groups (A). We also found  
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11 decreased suicide by firearms over the study period; while suicide by hanging sharply rose  
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13 among males (C). Figure 2 used 5-year periods to explore suicide of specific methods by age  
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15 groups and urban rural differences for a better visual effect. Suicide rates by firearms  
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17 decreased over the study period, especially in rural and remote areas (Figure 2B); while  
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19 suicide by hanging increased dramatically, reaching a peak in between 1996 and 2000,  
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21 especially in males (Figure 2A and 2B). Suicide rates by hanging in males dropped after 1997  
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23 but were still higher than the early years of the study period. Suicide rates by gases and  
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25 vapours, solid and liquid substances slightly fluctuated in the study period among all  
26  
27 population groups (Figure 2A and 2B). More details of suicide incidence trend over time in  
28  
29 each population group and suicide methods were indicated in Appendixes 1 and 2. Poisson  
30  
31 regression was implemented to examine the time series trend of suicide rates across  
32  
33 population groups and by methods (Table 2). Suicide rates by sexes, 55 years and over, in  
34  
35 urban areas, and completed by firearms, solid and liquid substances had significantly  
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37 decreased over time. However, suicide rates by hanging significantly increased in the study  
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39 period.  
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46 Figure 1 about here

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55 Figure 3 indicates that among 15 to 34 years, north and central south of Northern Territory  
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57 (NT), northeast and some southern parts of Western Australia (WA), northwest and central  
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3 inland areas of Queensland (QLD) and some inland areas of New South Wales (NSW) had  
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5 higher suicide mortalities (2A). The patterns were also similar for males (NT, QLD and WA  
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7 in B1). Population aged between 35 and 74 had fewer high-risk areas than that aged 15 to 34  
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9 (A2 and A3). For those aged 75 and over, mortalities in north and inland of QLD and a few  
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11 LGAs in NSW and WA was higher than other areas; around 40% of total LGAs and  
12  
13 unincorporated SLAs in NT and SA had no suicide occurred. Compared with males, more  
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15 areas, e.g., northeast NT, most of rural/remote areas in WA and inland QLD, had no female  
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17 suicide (2B). Rural and remote areas had lower rates by self-poison than urban areas, except  
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19 for some LGAs in inland QLD, east SA and south WA (2C).  
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24 Figure 3 about here

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26 As suicide rates by firearms and by hanging had more significant changes over time than  
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28 other methods and by population groups, we also explored whether this trend existed in  
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30 spatial scales over time by cutting the whole study period into four 5-year periods (Figure 4).  
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32 Figure 4A indicates that suicide rate by hanging was low in the early years of study period  
33  
34 (A1), and very few suicides occurred in rural and remote areas in WA, NT, QLD and NSW.  
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36 However, suicide by hanging kept increasing. North of WA, NT and SA, north of QLD and  
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38 even urban LGAs had much higher suicide rates between 1996 and 2005 compared with that  
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40 in earlier years. However, the trend of suicide by firearms was opposite to that of suicide by  
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42 hanging (Figure 4B), especially in SA and NT, north and inland areas in NSW and QLD, and  
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44 middle of WA (B1 and B2). In general, unincorporated NT and SA had much more suicide  
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46 cases reported after 1996 (123 from 1996 to 2005) compared with the period before 1996 (22  
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48 from 1986-1995).  
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53 Figure 4 about here

## 54 55 56 57 **DISCUSSION**

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3 This study explored suicide patterns in a range of different combinations of age, time,  
4 method, and location in Australia, using both dynamic (trends over time) and static (averages  
5 over the entire study period) approaches. Males accounted for most suicides. Suicide rate was  
6 relatively higher among youths, young and middle-aged adults, in rural and remote areas, and  
7 by hanging and by firearms. However, suicide rate among 55 years and over was higher than  
8 population aged below 55 in the early years of the study period and then decreased  
9 significantly, especially for older males. Suicide by firearms decreased during the study  
10 period, while suicide by hanging kept increasing, especially in males and rural/remote areas.  
11 The spatial and spatiotemporal patterns of suicide were consistent with yearly mean and  
12 temporal trends of suicide among different groups.  
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25 Suicidal behaviours among elderly and upper middle-aged adults (55-years and over) may be  
26 triggered from loneliness and other health issues (e.g., chronic diseases), which may lead to  
27 psychiatric symptoms, e.g., anxiety, sense of hopelessness.<sup>15 16</sup> Usually older adults are less  
28 likely to seek for psychiatric support when they have relevant symptoms, especially in earlier  
29 years (e.g., before the middle of 1990s).<sup>17</sup> Thus they had higher annual average suicide rate  
30 than younger age groups in general, especially among males. However, suicide rate among  
31 this age group gradually decreased in the study period, especially after 2000, with an  
32 increased use of antidepressants among older adults.<sup>18</sup> Evidence also indicates that  
33 antidepressants can reduce psychological disorders, e.g., depression, and suicidal behaviours  
34 among the elderly, especially when combined with other interventions (e.g., counselling and  
35 family support).<sup>19</sup> Selective serotonin reuptake inhibitors have less side effects (e.g.,  
36 cardiovascular impairs and drug interactions) than other drugs, and have been widely  
37 recommended to older adults from clinics.<sup>20 21</sup> However, little evidence has indicated that  
38 antidepressant use has significant effectiveness on youth suicide.<sup>20 21</sup> Studies in other  
39 countries have also provided evidence about the protective effect of antidepressants on severe  
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3 depression and suicide behaviours, although treatment of other levels of depression are still  
4 not clear.<sup>22 23</sup>  
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8 In 1986, firearms and other explosives were the most common methods of suicide in  
9 Australia, over 6 per 100,000 among males. However, the rate dropped to around 2 per  
10 100,000 in 2005. By contrast, male suicide rate by hanging rose from 3.8 per 100,000 in 1986  
11 to 9.4 per 100,000 in 2005, after experiencing a peak of 10.6 per 100,000 in 1998. A study in  
12 Victoria indicated that a decreased registration of firearms and lower and suicide rates were  
13 significantly correlated from 1997 to 2000 [24]. In this study, there were more decreased male  
14 suicide rate by firearms from period 1991-1995 to period 1996-2000 than other adjacent  
15 period (from period 1980-1990 to period 1991-1995, and from period 1996-2000 to period  
16 2001-2005) as Table 3 indicated. Thus it is suggestive that firearm law enforcement enacted  
17 in 1996 after the massacre in Tasmania, may have led to significant lower suicide rate by  
18 firearms over an extended period at the national level.<sup>24</sup> However, other studies indicated that  
19 decreased firearm suicide rate in young adults was accompanied with rising suicide rates by  
20 other methods at the national and local level.<sup>25 26</sup> Other countries also experienced decreased  
21 suicide rate by firearms and increased suicide rate by hanging over time.<sup>27 28</sup> This may due to  
22 increased substitute methods (e.g., hanging) for firearms.<sup>29</sup> Firearms usage has still been the  
23 most common method of suicide in the United States in recent years, even after a decrease in  
24 the previous decades.<sup>27</sup> Compared with United States, the pattern of suicide methods has  
25 changed more dramatically in Australia over time, due to stricter firearm control measures in  
26 Australia nationally than that in the US.<sup>26 27</sup> However, suicide rate by firearms in rural areas  
27 was higher than that in urban areas, owing much to the availability of firearms. More  
28 evidence, including the interaction between socio-economic changes and suicide methods,  
29 still needs to be assessed, especially for recent years.  
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57 Table 3 about here  
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3 Only a small percentage of population and suicides were for those aged 75 and over, thus  
4 many LGAs had no suicides or higher suicide rate among older adults, especially in rural and  
5 remote areas. Usually areas with high risk of suicide have lower socio-economic status, along  
6 with higher proportion of Indigenous population.<sup>10</sup> Our previous study indicated that  
7 Mornington Shire in QLD and Bathurst-Melville in north of NT had much higher suicide risk,  
8 proportion of Indigenous population and lower socio-economic status than the national  
9 average, and both were indicated as high risk clusters using spatial cluster analysis (1999-  
10 2003).<sup>10</sup> In this study, both of them experienced increased number of suicide cases between  
11 1996 and 2005 (27 in Mornington, 23 males and 26 by hanging; 23 in Bathurst-Melville, 22  
12 males and 20 by hanging), compared to that between 1986 and 1995 (4 in Mornington, male  
13 and 3 by hanging; 3 in Bathurst-Melville, male and by hanging). Population in Mornington  
14 Shire fluctuated from 718 (lowest, 1991 Census) to 1,111 (highest, 1996 Census) from 1986  
15 to 2005; and population in Bathurst-Melville increased from 1,811 (1986 Census) to 2,512  
16 (2006 Census). As a substitute, suicide by hanging has increased in Indigenous communities,  
17 as similar as other areas and population groups.<sup>28</sup> Alcohol has been introduced to the  
18 Aboriginal communities in Indigenous communities (e.g., Top North of NT and SA), and  
19 local people tended to be mentally and psychologically jeopardised by domestic violence and  
20 social disruptions related to alcohol use even from early years,<sup>30 31</sup> especially among youth  
21 and young adults.<sup>32</sup> Thus suicide behaviours were triggered from mental health problems after  
22 years of indirect influence from alcohol and can be spread quickly within an isolated  
23 community with limited population.<sup>33 34</sup> Family conflicts and social disruption have been  
24 reported contribution to the high suicide incidence in Indigenous population, e.g., lost of  
25 relatives in early lives due to a shorter life expectancy compared with non-Indigenous  
26 population, self-destructive and anti-social behaviours, unsolved anger and other life events.<sup>35</sup>  
27 Hanging acted as a substitute to other methods like firearms and poison, which may indicate  
28 that most Indigenous suicides were completed by hanging, especially after 1995.<sup>36</sup> Although  
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3 Indigenous status of suicide was not available in this study, yet the results were consistent  
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5 with previous studies. This mechanism may also explain the increased suicide cases in  
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7 unincorporated areas in NT (including Bathurst-Melville) and SA in general over the study  
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9 period.  
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12 The differences of suicide reporting systems may also influence the results. For example,  
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14 Williams et al reported that suicide rate in Queensland from the Queensland Suicide Register  
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16 (QSR) was higher than that from the Australian Bureau of Statistics (ABS), reasoning that the  
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18 disparity was due to such factors as information management and definition of suicidal  
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20 behaviours.<sup>37</sup> Compared with QSR, there were some underreported suicides not recorded in  
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22 the ABS database, especially in recent years. Thus the suicide rate in Queensland was lower  
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24 when using ABS data. However, ABS had a higher standard for evaluating the causes of  
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26 deaths, e.g., complete documents from hospital or police.<sup>38</sup> Some deaths were re-examined for  
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28 their reasons and confirmed as suicides after a few years of the date of the deaths. So the  
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30 information of current suicide deaths in the ABS database is accurate but some other suicides  
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32 may not have been recorded, especially in the database of recent years.  
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38 Recommendations on future research and public interventions can be proposed based on the  
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40 results of this study. Firstly, more details (e.g., health and financial status, alcohol and drugs  
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42 use, and family conflicts history) of suicide victims need to be acquired to help public health  
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44 policy makers and health workers to design and implement suicide control and prevention  
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46 strategies targeting particular population groups (e.g., male young adults) and areas (e.g.,  
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48 Indigenous communities). Suicide by firearms is still significant especially in rural and  
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50 remote areas. Thus effectiveness of control and prevention strategies e.g., firearm and  
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52 pesticide restrictions,<sup>39 40</sup> need to be evaluated. Gatekeeper education and training on rural  
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54 general practitioners are necessary in increasing their capacity of identifying local vulnerable  
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56 population (e.g., farmers and Indigenous population) and suicidal behaviours to reduce  
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3 potential suicide risk. Education of primary health workers and the general population are  
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5 vital in reducing suicidal behaviours,<sup>41-44</sup> and effectiveness of health education programs  
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7 needs to be assessed locally. The effectiveness of antidepressant use still need to explored and  
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9 improved, especially in youths and young adults.<sup>20</sup> These activities should be explored at a  
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11 local level, especially in high risk areas and population groups, to assess and improve the  
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13 effectiveness of suicide prevention programs. Potential impacts of socioeconomic<sup>45 46</sup> and  
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15 environmental factors<sup>47-49</sup> on suicide over time and space should also be addressed. As suicide  
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17 is a complex issue, cross-sectional and multi-disciplinary approaches need to be implemented  
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19 in suicide control and prevention in different levels (e.g., national, state and local). In  
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21 conclusion, this study has explored patterns of suicide across population groups and by  
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23 suicide methods over time and space. These results may have significant implication for  
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25 developing national suicide prevention strategies through focusing on high risk population  
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27 groups, local areas and specific suicide methods.  
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### 31 32 Competing interests

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34  
35 We declare that we have no competing interests.  
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### 38 39 Authors' contributions

40  
41 Xin Qi designed the study, implemented all statistical analyses and drafted the manuscript.  
42  
43 Shilu Tong conceptualised the idea and revised the study protocol, especially the research  
44  
45 design and data analysis. Wenbiao Hu provided advice on statistical analyses and  
46  
47 interpretation of the results. Andrew Page helped interpreting the results and drafting the  
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49 manuscript. All the authors contributed to the preparation of the final manuscript and  
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51 approved the submission.  
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10 Figure 1: suicide rates over time and sub-groups (per 100,000)

11 A: Sex and age groups; B: Sex and urban rural differences; C: Sex and methods;  
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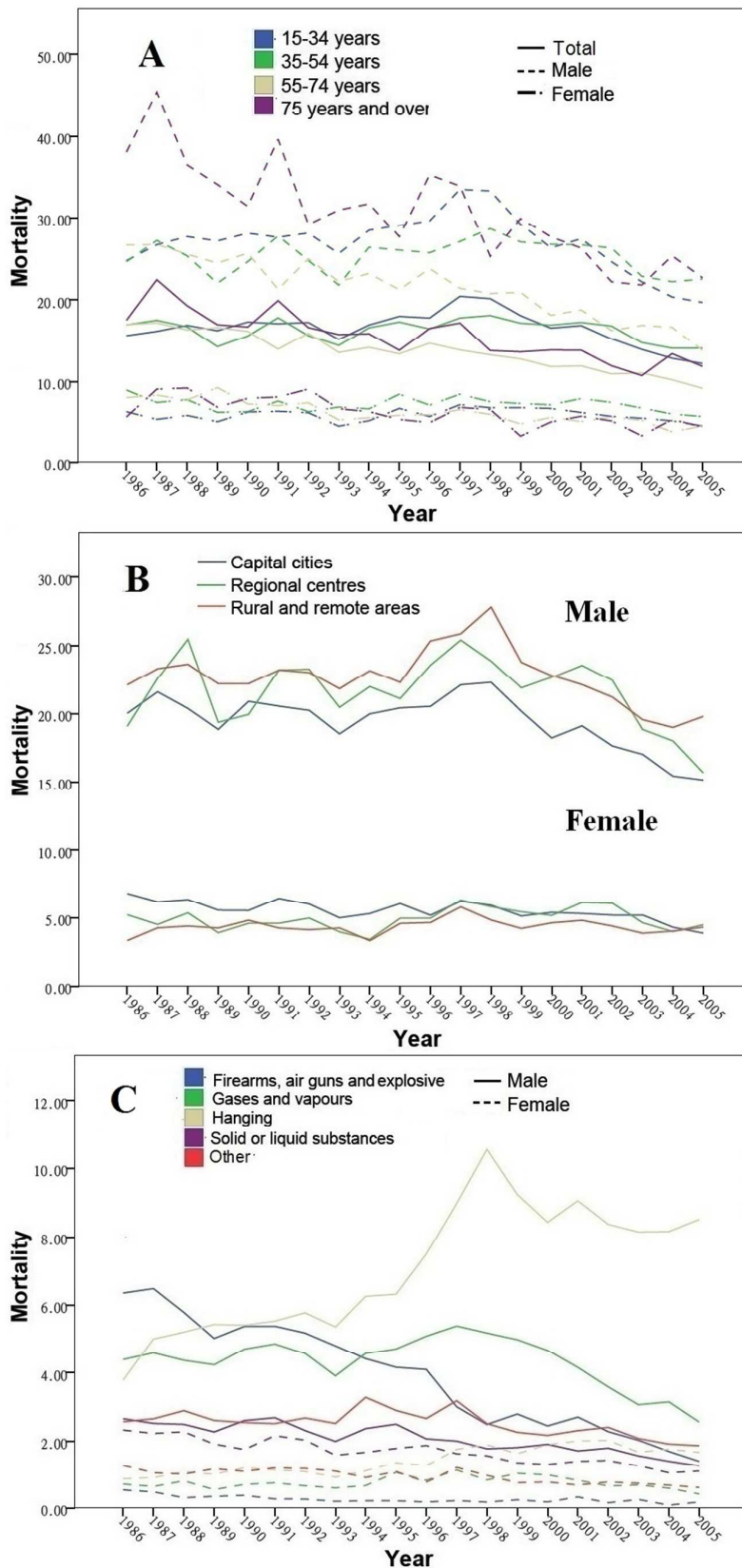


Figure 2: suicide rates over time and methods (per 100,000, annual average)

A: Methods and age groups: B: Methods and urban rural difference

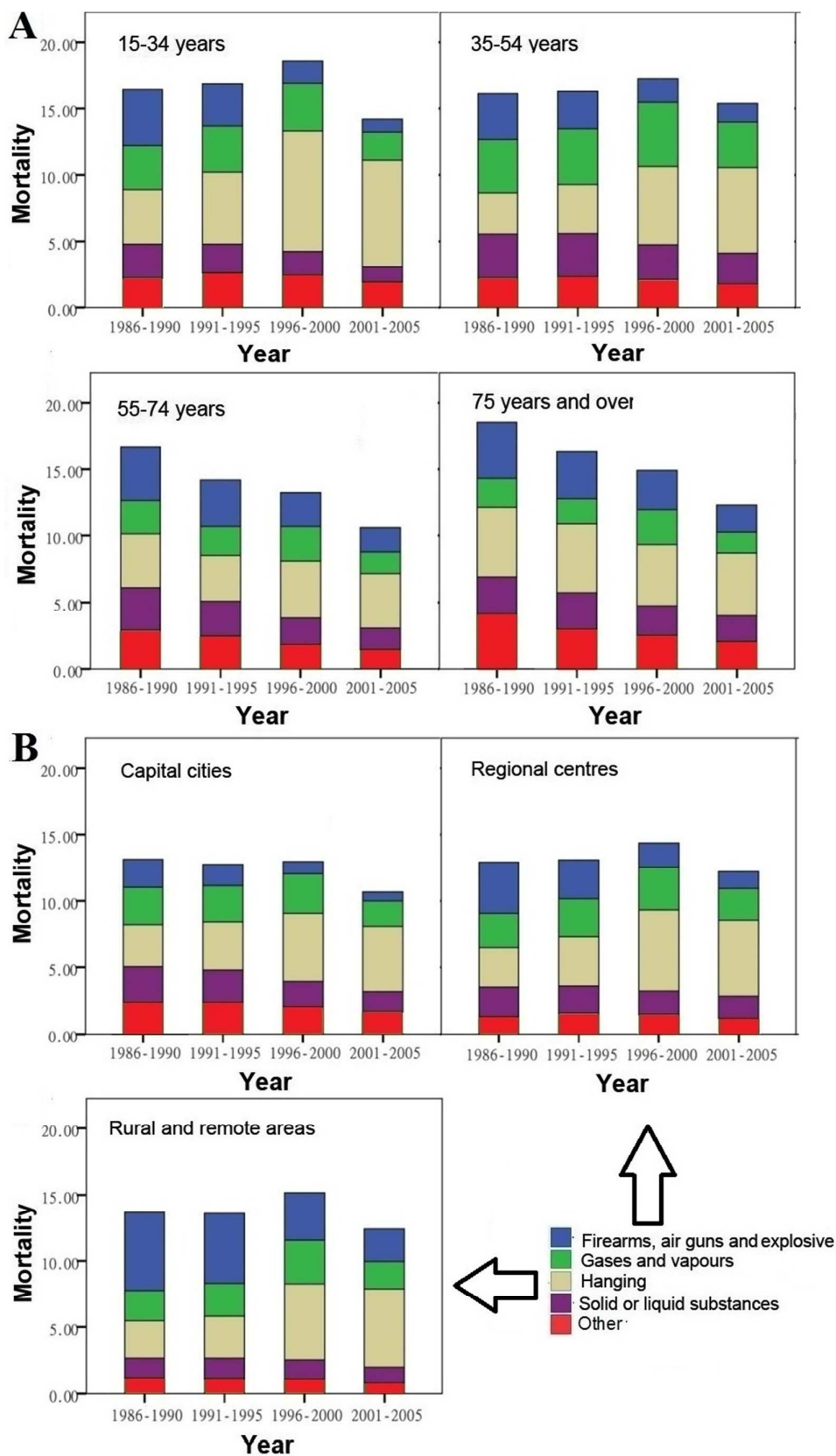


Figure 3: Suicide rates among different groups across Australia (1986-2005)

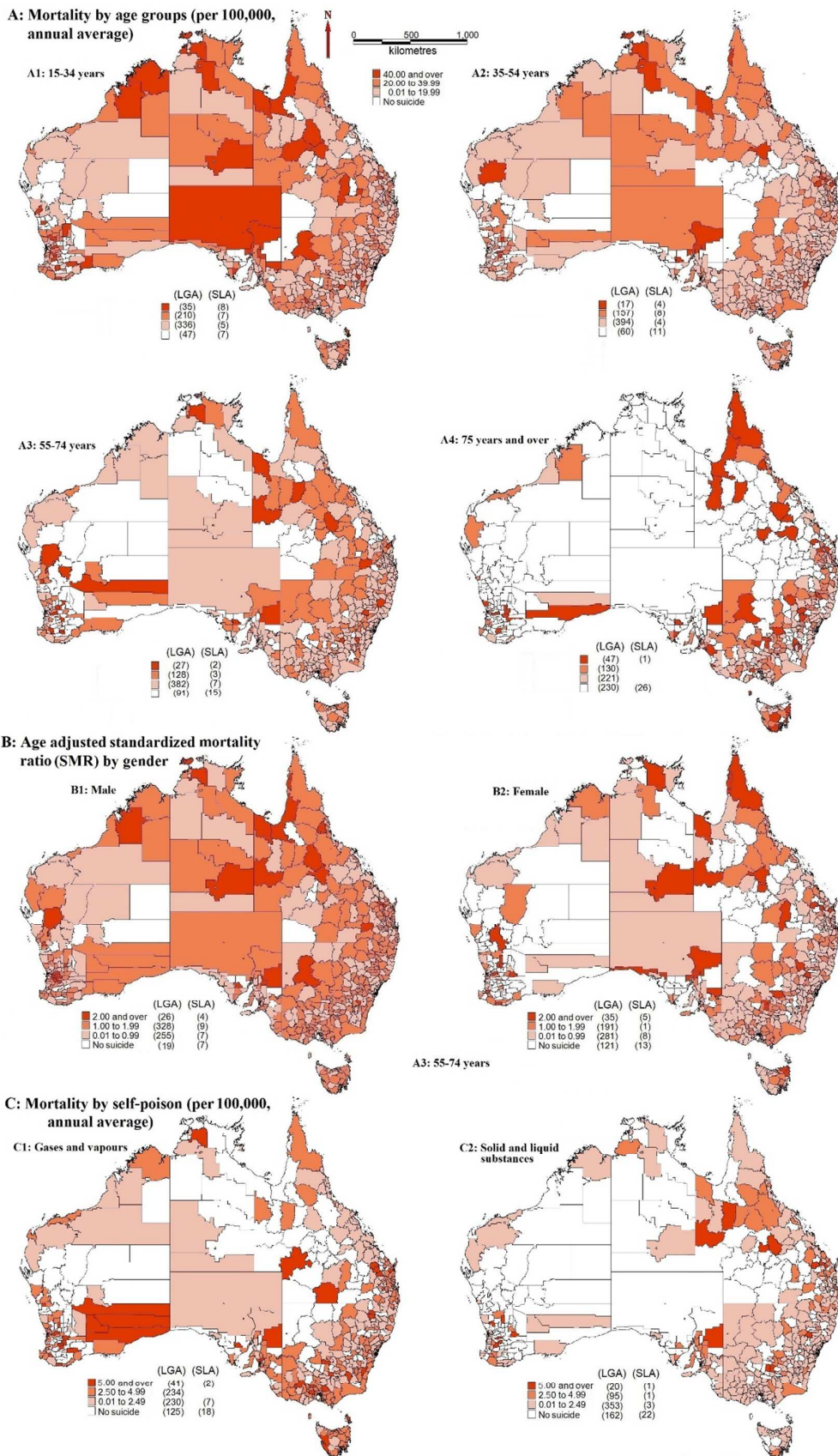
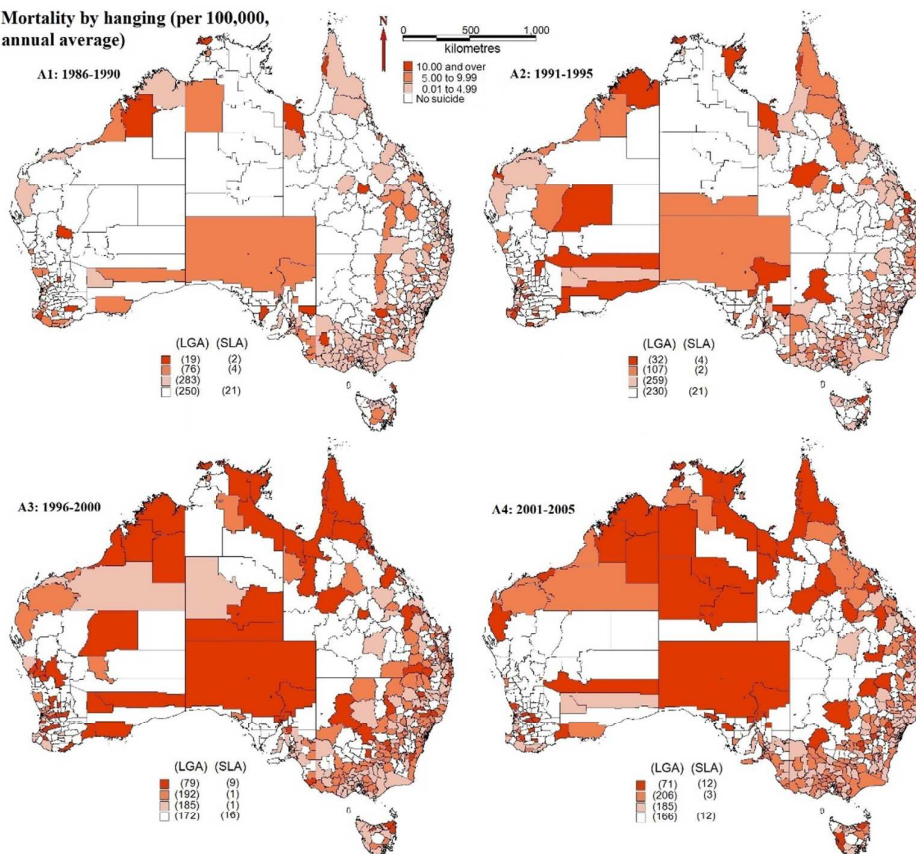
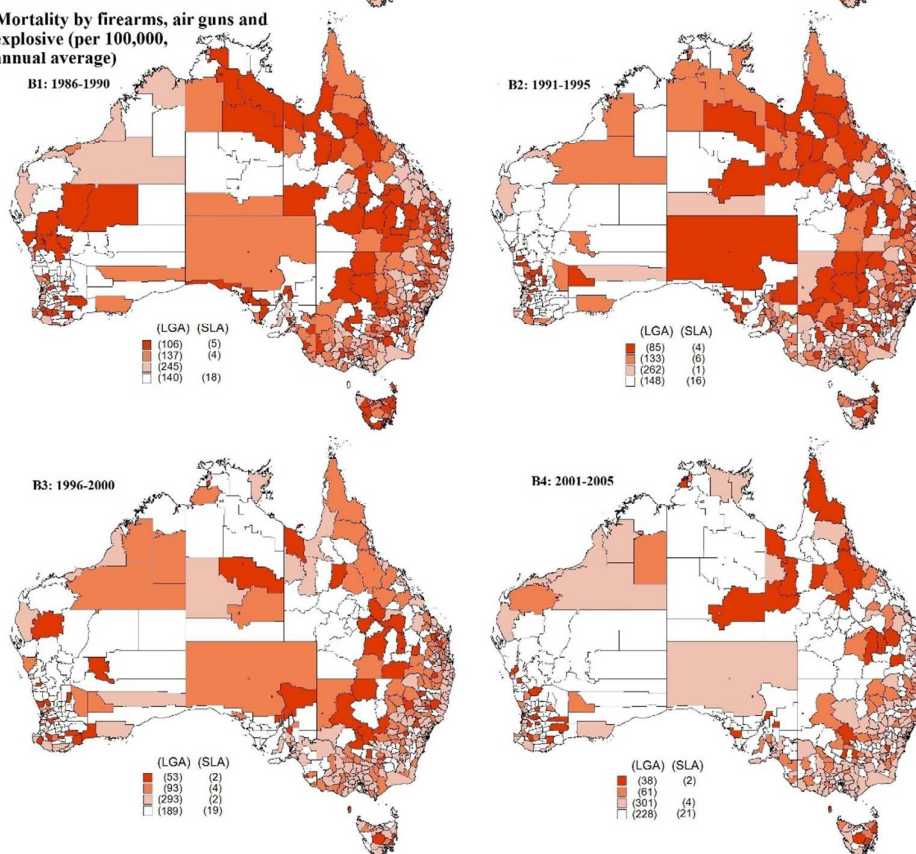


Figure 4: Suicide rates by self-harm over time and across space in Australia (1986-2005)

**A: Mortality by hanging (per 100,000, annual average)**



**B: Mortality by firearms, air guns and explosive (per 100,000, annual average)**



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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)
<b>By sex</b>															
Male	15,059	28.29	2.23 (2.19, 2.27)	12,672	25.61	2.02 (1.98, 2.06)	5,986	22.35	1.77 (1.72, 1.81)	2,091	30.98	2.45 (2.34, 2.56)	35,942	20.32	1.61 (1.58, 1.63)
Female	3,242	6.12	0.48 (0.47, 0.50)	3,556	7.14	0.56 (0.55, 0.58)	1,818	6.48	0.51 (0.49, 0.54)	682	6.14	0.49 (0.45, 0.52)	9,351	5.17	0.41 (0.40, 0.42)
<b>By region</b>															
Capital cities	11,267	16.28	1.29 (1.26, 1.31)	9,736	15.68	1.24 (1.21, 1.27)	4,568	14.21	1.12 (1.09, 1.16)	1,674	15.45	1.22 (1.16, 1.28)	27,332	12.32	0.97 (0.96, 0.99)
Regional centres	3,423	17.57	1.39 (1.34, 1.44)	3,269	17.72	1.40 (1.35, 1.45)	1,550	13.65	1.03 (1.03, 1.14)	584	15.96	1.26 (1.16, 1.37)	8,869	12.86	1.02 (1.00, 1.04)
Rural & remote areas	3,611	20.58	1.63 (1.57, 1.68)	3,223	17.23	1.36 (1.31, 1.41)	1,686	14.88	1.18 (1.12, 1.23)	515	15.37	1.21 (1.11, 1.32)	9,092	13.55	1.07 (1.05, 1.09)
<b>By methods</b>															
Firearms & other explosives	2,795	2.63	0.21 (0.20, 0.22)	2,285	2.30	0.18 (0.18, 0.19)	1,674	3.05	0.24 (0.23, 0.25)	556	3.11	0.25 (0.23, 0.27)	7,348	2.07	0.16 (0.16, 0.17)
Gases & vapours	3,457	3.25	0.26 (0.25, 0.27)	4,104	4.13	0.33 (0.32, 0.34)	1,277	2.33	0.18 (0.17, 0.20)	375	2.10	0.17 (0.15, 0.18)	9,214	2.60	0.20 (0.20, 0.21)
Hanging	7,366	6.93	0.55 (0.54, 0.56)	4,927	4.96	0.39 (0.38, 0.41)	2,301	4.20	0.33 (0.32, 0.35)	901	5.05	0.40 (0.37, 0.43)	15,620	4.40	0.35 (0.34, 0.35)
Solid or liquid substances	2,166	2.04	0.16 (0.16, 0.17)	2,863	2.88	0.23 (0.22, 0.24)	1,333	2.43	0.19 (0.18, 0.20)	434	2.43	0.19 (0.18, 0.21)	6,807	1.92	0.15 (0.15, 0.15)
Other	2,517	1.26	0.19 (0.18, 0.20)	2,049	2.06	0.16 (0.16, 0.17)	1,219	2.22	0.18 (0.17, 0.19)	507	2.84	0.23 (0.21, 0.25)	6,294	1.78	0.14 (0.14, 0.14)
<b>By region and by sex</b>															
Male															
Capital cities	9,072	26.66	2.08 (2.03, 2.13)	7,439	24.59	1.92 (1.87, 1.97)	3,358	21.86	1.71 (1.65, 1.77)	1,179	30.02	2.35 (2.22, 2.49)	21,107	19.63	1.53 (1.51, 1.56)
Regional centres	2,868	29.90	2.33 (2.25, 2.42)	2,593	28.60	2.23 (2.15, 2.32)	1,213	22.21	1.74 (1.64, 1.84)	468	32.80	2.57 (2.35, 2.81)	7,173	21.39	1.67 (1.63, 1.71)
Rural/remote areas	3,119	32.46	2.72 (2.62, 2.82)	2,640	25.99	2.16 (2.08, 2.24)	1,415	23.73	1.94 (1.84, 2.04)	444	31.82	2.60 (2.37, 2.85)	7,662	21.39	1.77 (1.73, 1.82)
Female															
Capital cities	2,195	6.40	0.50 (0.48, 0.52)	2,297	7.39	0.58 (0.55, 0.60)	1,210	7.33	0.57 (0.54, 0.61)	495	7.26	0.57 (0.52, 0.62)	6,225	5.58	0.44 (0.42, 0.45)
Regional centres	555	5.75	0.45 (0.42, 0.49)	676	7.37	0.58 (0.53, 0.62)	337	5.83	0.46 (0.41, 0.51)	116	5.27	0.41 (0.34, 0.50)	1,696	4.91	0.38 (0.37, 0.40)
Rural/remote areas	492	5.43	0.43 (0.39, 0.47)	583	6.12	0.51 (0.47, 0.55)	271	4.71	0.39 (0.34, 0.43)	71	3.41	0.28 (0.22, 0.35)	1,430	4.13	0.34 (0.33, 0.36)
<b>By methods and by region</b>															
Capital cities															
Firearms & other explosives	1,148	1.66	0.13 (0.12, 0.14)	913	1.47	0.12 (0.11, 0.12)	626	1.95	0.15 (0.14, 0.17)	211	1.95	0.16 (0.14, 0.18)	2,908	1.31	0.10 (0.10, 0.11)
Gases & vapours	2,299	3.32	0.26 (0.25, 0.27)	2,420	3.90	0.31 (0.30, 0.32)	732	2.28	0.18 (0.17, 0.19)	222	2.05	0.16 (0.14, 0.19)	5,674	2.56	0.20 (0.20, 0.21)
Hanging	4,339	6.27	0.50 (0.48, 0.51)	3,017	4.86	0.38 (0.37, 0.40)	1,470	4.57	0.36 (0.34, 0.38)	591	5.45	0.43 (0.40, 0.47)	9,478	4.27	0.30 (0.30, 0.31)
Solid or liquid substances	1,547	2.24	0.18 (0.17, 0.19)	1,864	3.00	0.24 (0.23, 0.25)	901	2.80	0.22 (0.21, 0.24)	284	2.62	0.21 (0.19, 0.23)	4,600	2.07	0.16 (0.16, 0.17)
Other	1,934	2.79	0.22 (0.21, 0.23)	1,522	2.45	0.19 (0.18, 0.20)	839	2.61	0.21 (0.19, 0.22)	366	3.38	0.27 (0.24, 0.30)	4,672	2.11	0.17 (0.16, 0.17)
Regional centres															
Firearms & other explosives	603	3.09	0.25 (0.23, 0.27)	495	2.68	0.21 (0.20, 0.23)	368	3.24	0.26 (0.23, 0.28)	131	3.58	0.28 (0.24, 0.33)	1,606	2.33	0.19 (0.18, 0.19)
Gases & vapours	631	3.24	0.26 (0.24, 0.28)	861	4.67	0.37 (0.35, 0.40)	275	2.42	0.19 (0.17, 0.22)	91	2.49	0.20 (0.16, 0.24)	1,858	2.70	0.21 (0.20, 0.22)
Hanging	1,502	7.71	0.61 (0.58, 0.64)	1,026	5.56	0.44 (0.41, 0.47)	456	4.02	0.32 (0.29, 0.35)	187	5.11	0.40 (0.35, 0.46)	3,200	4.65	0.37 (0.36, 0.38)
Solid or liquid substances	344	1.77	0.14 (0.13, 0.16)	570	3.09	0.25 (0.23, 0.27)	258	2.27	0.18 (0.16, 0.20)	92	2.51	0.20 (0.16, 0.24)	1,268	1.84	0.15 (0.14, 0.15)
Other	343	1.76	0.14 (0.13, 0.16)	317	1.72	0.14 (0.12, 0.15)	193	1.70	0.14 (0.12, 0.16)	83	2.27	0.18 (0.15, 0.22)	937	1.36	0.11 (0.10, 0.12)



Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005, continued)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)	Cases	Rate	RR (95% CI)
<b>Rural/remote areas</b>															
Firearms & other explosives	1,044	5.95	0.47 (0.44, 0.50)	877	4.69	0.37 (0.35, 0.40)	680	6.00	0.48 (0.44, 0.51)	214	6.39	0.51 (0.44, 0.52)	2,834	4.22	0.33 (0.32, 0.35)
Gases & vapours	527	3.00	0.24 (0.22, 0.26)	823	4.40	0.35 (0.33, 0.37)	270	2.38	0.19 (0.17, 0.21)	62	1.85	0.15 (0.11, 0.19)	1,682	2.51	0.20 (0.19, 0.21)
Hanging	1,525	8.69	0.69 (0.65, 0.72)	884	4.73	0.37 (0.35, 0.40)	375	3.31	0.26 (0.24, 0.29)	123	3.67	0.29 (0.24, 0.35)	2,942	4.38	0.35 (0.33, 0.36)
Solid or liquid substances	275	1.57	0.12 (0.11, 0.14)	429	2.29	0.18 (0.17, 0.20)	174	1.54	0.12 (0.11, 0.14)	58	1.73	0.14 (0.11, 0.18)	939	1.40	0.11 (0.10, 0.12)
Other	240	1.37	0.11 (0.10, 0.12)	210	1.12	0.09 (0.08, 0.10)	187	1.65	0.13 (0.11, 0.15)	58	1.73	0.14 (0.11, 0.18)	695	1.04	0.08 (0.08, 0.09)
<b>By methods and by sex</b>															
<b>Male</b>															
Firearms & other explosives	2,555	4.80	0.38 (0.37, 0.40)	2,123	4.29	0.34 (0.33, 0.36)	1,605	5.99	0.48 (0.45, 0.50)	551	8.16	0.65 (0.60, 0.70)	6,869	3.88	0.31 (0.30, 0.32)
Gases & vapours	2,961	5.56	0.44 (0.42, 0.46)	3,428	6.93	0.55 (0.53, 0.57)	1,091	4.07	0.32 (0.30, 0.34)	324	4.80	0.38 (0.34, 0.43)	7,805	4.41	0.35 (0.34, 0.36)
Hanging	6,267	11.77	0.93 (0.91, 0.96)	4,115	8.32	0.66 (0.64, 0.68)	1,821	6.80	0.54 (0.51, 0.56)	670	9.93	0.79 (0.73, 0.85)	12,963	7.33	0.58 (0.57, 0.59)
Solid or liquid substances	1,301	2.44	0.19 (0.18, 0.20)	1,573	3.18	0.25 (0.24, 0.27)	671	2.51	0.20 (0.18, 0.21)	198	2.93	0.23 (0.20, 0.27)	3,746	2.12	0.17 (0.16, 0.17)
Other	1,975	3.72	0.29 (0.28, 0.31)	1,433	2.89	0.23 (0.22, 0.24)	798	2.98	0.24 (0.22, 0.25)	348	5.16	0.41 (0.37, 0.46)	4,559	2.58	0.20 (0.20, 0.21)
<b>Female</b>															
Firearms & other explosives	240	0.45	0.04 (0.03, 0.04)	162	0.33	0.03 (0.02, 0.03)	69	0.25	0.02 (0.02, 0.03)	5	0.05	0.00 (0.00, 0.01)	479	0.26	0.02 (0.02, 0.02)
Gases & vapours	496	0.94	0.07 (0.07, 0.08)	676	1.36	0.11 (0.10, 0.12)	186	0.66	0.05 (0.05, 0.06)	51	0.46	0.04 (0.03, 0.05)	1,409	0.78	0.06 (0.06, 0.07)
Hanging	1,099	2.07	0.16 (0.15, 0.17)	812	1.63	0.12 (0.11, 0.13)	480	1.71	0.14 (0.12, 0.15)	231	2.08	0.17 (0.15, 0.19)	2,657	1.47	0.12 (0.11, 0.12)
Solid or liquid substances	865	1.63	0.13 (0.12, 0.14)	1,290	2.59	0.21 (0.19, 0.22)	662	2.36	0.19 (0.17, 0.20)	236	2.13	0.17 (0.15, 0.19)	3,061	1.69	0.13 (0.13, 0.14)
Other	542	1.03	0.08 (0.07, 0.09)	616	1.23	0.10 (0.09, 0.11)	421	1.50	0.12 (0.11, 0.13)	163	1.42	0.12 (0.10, 0.14)	1,745	0.97	0.08 (0.07, 0.08)
<b>Total suicide</b>	<b>18,301</b>	<b>17.23</b>	<b>1.36 (1.34, 1.38)</b>	<b>16,228</b>	<b>16.35</b>	<b>1.29 (1.27, 1.32)</b>	<b>7,804</b>	<b>14.23</b>	<b>1.12 (1.10, 1.15)</b>	<b>2,773</b>	<b>15.54</b>	<b>1.23 (1.18, 1.28)</b>	<b>45,293</b>	<b>12.66</b>	

Note: population size (all and by groups) was based on the mean value of Australian population census (1986, 1991, 1996, 2001, 2006). Relative risk (RR) was calculated using the mean annual suicide rate of the whole country as a reference.

Table 2: Suicide rate change over time (population groups and suicide methods)

	RR	95% CI	P-value
All suicide	0.99	0.99, 0.99	<0.001
Male	0.99	0.99, 0.99	<0.001
Female	0.99	0.99, 0.99	<0.001
Age 15-34	0.99	0.99, 1.00	<0.001
Age 35-54	1.00	0.99, 1.00	0.009
Age 55-74	0.97	0.97, 0.98	<0.001
Age 75 & over	0.97	0.97, 0.98	<0.001
Urban areas	0.99	0.99, 0.99	0.001
Regional areas	1.00	0.99, 1.00	0.019
Rural & remote areas	1.00	0.99, 1.00	0.022
Firearm	0.93	0.93, 0.94	<0.001
Hanging	1.04	1.03, 1.04	<0.001
Gas and vapour	0.99	0.98, 0.99	<0.001
Solid or liquid substances	0.97	0.96, 0.97	<0.001
Other methods	0.98	0.98, 0.98	<0.001

Table 3: Male suicide rate by firearms change over time (Reference: mean annual male suicide rate in 1986-1990 by each of age groups and types of regions)

Population group	Time period	RR	95% CI	P-value
15-34 yrs	2001-2005	0.22	0.08, 0.36	<0.001
	1996-2000	0.39	0.28, 0.51	<0.001
	1991-1995	0.78	0.69, 0.87	<0.001
35-54 yrs	2001-2005	0.39	0.26, 0.51	<0.001
	1996-2000	0.52	0.40, 0.64	<0.001
	1991-1995	0.83	0.72, 0.94	0.001
55-74 yrs	2001-2005	0.43	0.28, 0.57	<0.001
	1996-2000	0.63	0.49, 0.76	<0.001
	1991-1995	0.88	0.75, 1.01	0.049
75 yrs & over	2001-2005	0.45	0.21, 0.69	<0.001
	1996-2000	0.66	0.43, 0.89	<0.001
	1991-1995	0.83	0.59, 1.06	0.103
Capital cities	2001-2005	0.33	0.21, 0.45	<0.001
	1996-2000	0.46	0.35, 0.57	<0.001
	1991-1995	0.78	0.69, 0.88	<0.001
Regional centres	2001-2005	0.32	0.17, 0.48	<0.001
	1996-2000	0.47	0.33, 0.61	<0.001
	1991-1995	0.78	0.65, 0.90	<0.001
Rural and remote areas	2001-2005	0.41	0.29, 0.53	<0.001
	1996-2000	0.61	0.50, 0.72	<0.001
	1991-1995	0.91	0.81, 1.00	0.048

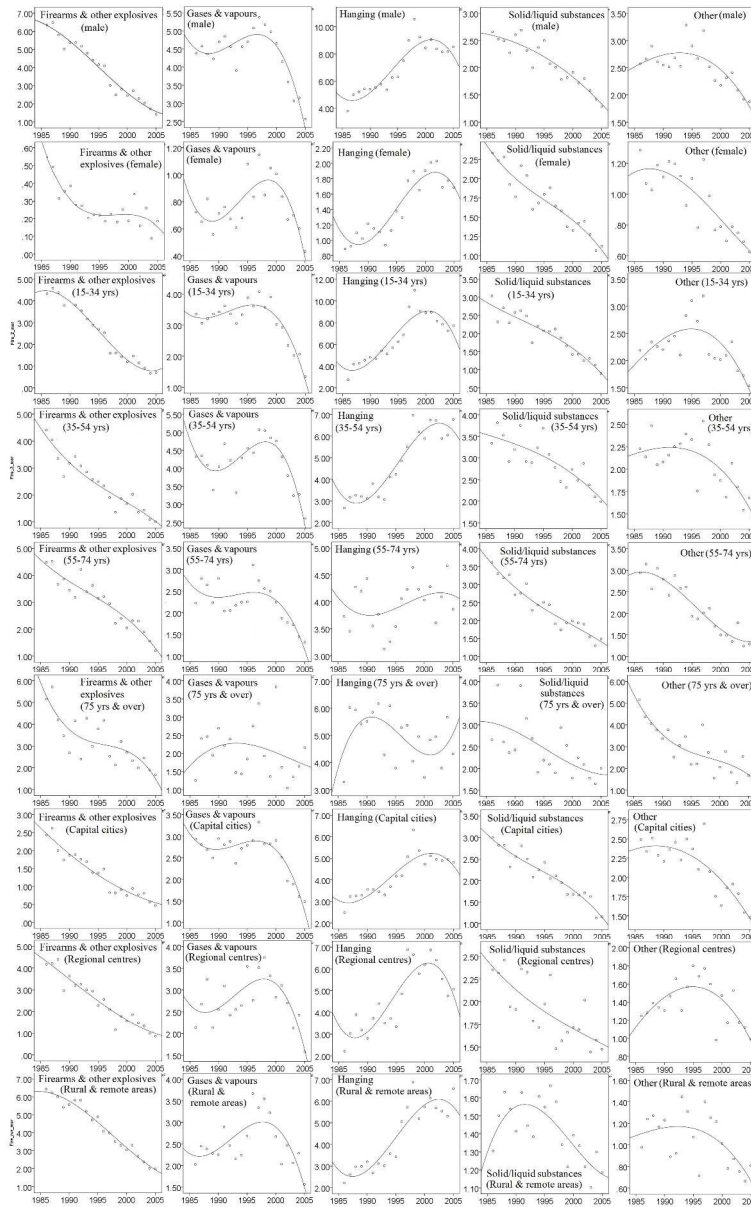
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Supplemental 1: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 1).

Supplemental 2: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 2).

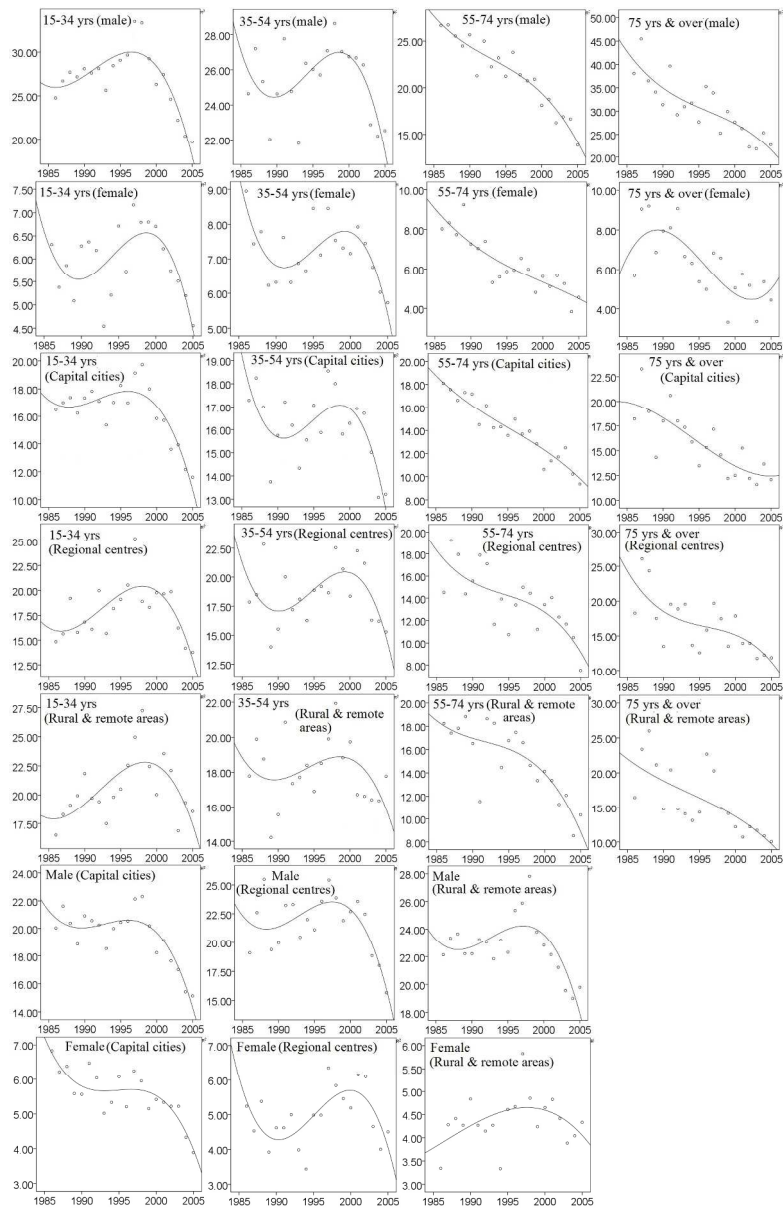
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## Dynamic pattern of suicide in Australia, 1986–2005

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# Dynamic pattern of suicide in Australia, 1986–2005

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## ABSTRACT

**Objective:** This study explored the spatiotemporal variations of suicide across Australia from 1986 to 2005, discussed the reasons for dynamic changes and recommended future suicide research and prevention strategies.

**Design:** Suicide (1986–2005) and population data were obtained from the Australian Bureau of Statistics. A series of analyses were conducted to examine the suicide pattern by sex, method and age group over time and space.

**Results:** Apparent differences in suicide rates across sex, age groups and suicide methods were found across different geographical areas. Male suicides were mainly completed by hanging, firearms, gases and poison. Female suicides were primarily completed by hanging and poison. Suicide rates were high in rural areas than urban areas (capital cities and regional centres). Suicide rate by firearms was higher in rural areas than urban areas, while the pattern for poison was opposite. Suicide rates slightly fluctuated for total population and aged between 15 and 54, while suicide decreased among 55 years and over during the study period. There was a decrease of suicide by firearms during the study period especially after 1996 when new firearm control law was implemented; while suicide by hanging kept increasing. Some areas with a high proportion of Indigenous population (e.g., northwest of Queensland and top north of Northern Territory) had a high increase of suicide incidence after 1995.

**Conclusions:** Suicide rates varied over time and space and across sexes, age groups, suicide methods. Suicide control and prevention strategies should target particular groups and areas of high and increased risk (e.g., Indigenous communities).

**Key words:** suicide, Australia, pattern

## STRENGTHS AND LIMITATIONS OF THE STUDY

This study used various cross-tabulations with the 20-year Australian national suicide data cut in different ways (e.g., population group, suicide methods, time and space), and provides valuable information for examining suicide trends in Australia.

The different suicide rates across population groups and by suicide methods were presented, which may help in designing effective suicide control and prevention programs. Different levels of spatial scales (Local Government Area (LGA) and Statistical Local Area (SLA)) were combined to best display the spatial distribution of suicide patterns; and the boundary changes over years were also adjusted using advanced GIS methods.

This study only examined the suicide pattern at the population level using aggregated data. Detailed individual information such as marriage, employment, Indigenous status and health status before suicide was not available in the current dataset. Thus ecological fallacy is inevitable in this study and the results should be cautious when interpreted at the individual level.

The quality of suicide data may influence the results of the study. There is evidence suggesting that some suicide deaths were not covered in the current ABS database. The real suicide rate may be underestimated so the results should be interpreted with caution.

The suicide database was acquired a few years ago and may not indicate the trend of suicide after 2005.

## INTRODUCTION

Suicide has long been regarded as a major public health issues globally, with about 1 million suicide deaths annually.<sup>1</sup> Suicide patterns, including suicide methods, time and geographical variation have been explored in many countries and regions, such as Brazil,<sup>2</sup> China,<sup>3</sup> India,<sup>4</sup> Russia,<sup>5</sup> Taiwan,<sup>6</sup> United Kingdom,<sup>7</sup> and United States.<sup>8</sup> In Australia, suicide rates have fluctuated since suicide registration started in the early of 1920s.<sup>9-11</sup> The trend of annual suicide rate from 1980 to now was relatively stable (around 9 to 10 per 100,000) except for a peak in 1997 (around 14.6 per 100,000).<sup>9-11</sup> However, there were still around 2,000 suicide deaths annually, mainly in male adults (25-54 years age). Thus, it is vital to understand the variations of suicide patterns over time, space, population groups (age, sex and ethnic groups) and the possible reasons for these variations, in order to design effective suicide control and prevention programs. Previous reports and studies have explored suicide patterns in Australia over time,<sup>9-12</sup> methods<sup>13</sup> and space.<sup>14</sup> From geographical aspect, Australian Bureau of Statistics (ABS) suicide reports covered a long period (1921 to 2010) and targeted at the state level and capital cities.<sup>9-11</sup> However, suicide patterns at the smaller area (e.g., Local Government Area, or LGA) level, especially in rural and remote areas, were not provided by the ABS reports. The study by Cheung et al examined the spatial pattern of suicide in Australia after 2000.<sup>15</sup> However, this study did not examine suicide pattern before 2000 or by suicide methods; thus the dynamic spatial pattern of suicide and high risk areas of suicide by particular method (e.g., firearms) could not be demonstrated. ABS reports indicated that most suicide occur in urban areas in Australia, while less suicide were recorded in rural and remote areas covering of most Australian land territory but with a lower population density. Thus it is vital in selecting suitable spatial scales in examining spatial pattern of suicide in Australia. The studies of spatial pattern of suicide in earlier years (e.g. before 1995) used relative large spatial scales (e.g., Statistical Division rather than LGA), which may mask the spatial

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variation of suicide in some rural areas (e.g., in Western Australia and Northern Territory) due to their large size.<sup>16 17</sup> The spatial patterns of suicide by different population groups and suicide methods over a long term covering both of previous years (e.g., before 2000) and more recent years (after 2000) using suitable spatial scales (e.g., LGA) have not yet been examined. The trends of suicide rates over time may differ across population groups (e.g., young or older adults) and areas (e.g., suicide by firearms in urban or rural areas). Thus, this study examined long-term (both dynamic and static), spatiotemporal patterns of Australian national suicide, using a range of different combinations of age, time, method, and location from the period 1986-2005.

## DESIGN

### Data source

The unit record data of suicide deaths between 1986 and 2005 were acquired from Australian Bureau of Statistics (ABS), including sex, International Classification of Disease (ICD) Code (ICD 9: 950.0-959.9; ICD 10: X60-X84)<sup>18 19</sup> relating to suicide or self-inflicted injury, age, country of birth, date of suicide and Statistical Local Area (SLA) code for place of suicide occurrence. The application of access to suicide database after 2005 is still under review by ABS. As SLA boundaries have changed dramatically over the study period, especially in urban areas, we chose Local Governmental Area (LGA) as the standard geographical unit to explore the spatial pattern of suicide. Choosing LGA as the spatial scale also aims to keep the balance of including a certain number of suicide in each geographical unit and avoiding using too large geographical unit. Each LGA is composed of one or more SLAs and the LGA boundaries are relatively stable over the study period. The Australian Standard Geographical Classification (ASGC), updated annually, was used to incorporate SLA codes into LGA codes, examine and adjust for SLA/LGA boundary changes over time. CDATA 2001, a

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2  
3 product issued by ABS, provided digital boundaries and socio-demographic data of Australia  
4 (including 1991, 1996 and 2001 population census data at SLA/LGA levels, based on 2001  
5 Census boundary) and was applied in MapInfo 10.5 software package for map display.<sup>20</sup>  
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7 Population data (SLA/LGA levels) in 1986 and 2006 Census from ABS were merged with  
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9 2001 Census data after adjustment for boundary changes using ASGC references. The suicide  
10 rates in different groups over time and across LGAs were then calculated. In this study, we  
11  
12 categorize LGAs as three types: metropolitan areas of capital cities, regional centres (other  
13 LGA named as “city” outside of capital cities, e.g., City of Townville), rural and remote areas  
14 (the remaining LGAs).  
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23 Most areas in South Australia (SA) and Northern Territory (NT) have a very low population  
24 density and were defined as unincorporated areas by ABS at the LGA level, but these areas  
25 were also composed of 27 SLAs according to the 2001 Census data. Thus we applied SLA  
26 data in unincorporated areas in SA and NT to provide more detailed information. In the 2001  
27 Census, Australia was divided into 628 LGAs, plus 27 SLAs in the unincorporated areas of  
28 SA and NT. Ethical approval was granted by the Human Research Ethics Committee,  
29 Queensland University of Technology.  
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### 39 **Statistical analyses**

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42 Descriptive and mapping approaches were applied to explore the age, sex, method, time and  
43 regional-specific patterns of suicide cases and rates. Firstly, we explored the basic pattern of  
44 suicide among different groups by calculating suicide rates, Rate Ratio and 95% Confident  
45 Interval (CI) to annual mean of national suicide rate over the study period using the annual  
46 average suicide number in the whole Australia and population (1986-2005) as reference  
47 group. Then the temporal trends of suicide rates in population groups were examined, using  
48 yearly data and Poisson regression. Suicide in 1986 and by methods and population groups  
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2 was the reference group and we used logarithm transferred population size in different years  
3 as an offset in Poisson regression. Suicide year was regarded as a covariate. All the statistical  
4 analyses were implemented by SPSS 21.0.<sup>21</sup> Finally suicide rates at the LGA level were  
5 applied to display suicide rates over sexes, age groups and suicide methods using mapping  
6 approaches by MapInfo 10.5.<sup>20</sup> We used the annual average sex-specific rates for the whole of  
7 Australia over the entire study period as the reference to calculate age-adjusted standardised  
8 mortality ratio (SMR) of both sexes which were mapped.  
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## 19 RESULTS

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21 This study included 45,293 suicide deaths in 20 years and only 187 suicides aged below 15,  
22 about 0.4% of total suicides. Thus we did not specifically analyse the pattern of suicide below  
23 15 years; however, we still keep them in results of all-age groups. Table 1 indicates that most  
24 of suicides occurred in those aged between 15 and 54 and occurred in capital cities and  
25 regional centres, as the majority of Australian population live in urban areas. However,  
26 suicide rate in rural and remote areas was higher than that in urban areas. Around 80% of  
27 suicides were males and most suicides aged between 15 and 54 years, while older males (75-  
28 year and over) had higher suicide rate than males in other age groups. Most suicides were in  
29 four methods: (1) firearms, air guns and other explosive (simplified as firearms, 16% of total  
30 suicides); (2) hanging (35% of total); (3) gases and vapours (20% of total); (4) solid or liquid  
31 substances (15% of total). The Odds Ratio (OR) and 95% Confident Interval (CI) of suicide in  
32 each population group and by different methods were calculated, using annual average suicide  
33 incidence in the study period in Australia as a reference (Table 1). We also applied Chi square  
34 test to check the suicide cases distribution by population groups and methods, and all the  
35 results are significant.  
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Figure 1 shows the time-series trends of suicide by different groups. There was a peak of suicide rate among the total population from 1996 to 1998, particularly in males aged from 15 to 34 years (A), males in rural and remote areas (B) and suicide completed by hanging (C). In the early years of the study period, suicide incidence among 55 years and over was higher than those below 55 years, however, it was observed to drop lower than that of young and middle aged adults after 2000, particular in males (A). Suicide rate among 15 to 34 years had peaks in 1997 and 1998 (especially for male at around 34 per 100,000 and total at around 21 per 100,000) and kept relatively steady in other years (14 to 17 per 100,000 for total and 25 to 28 per 100,000 for male) (A). In 1986, firearms and other explosives were the most common methods of suicide in Australia, over 6 per 100,000 among males. However, the rate dropped to around 2 per 100,000 in 2005. By contrast, male suicide rate by hanging rose from 3.8 per 100,000 in 1986 to 9.4 per 100,000 in 2005, after experiencing a peak of 10.6 per 100,000 in 1998 (C). Suicide rates by hanging in males dropped after 1997 but were still higher than the early years of the study period. Figure 2 used 5-year periods to explore suicide of specific methods by age groups and urban rural differences for a better visual effect. Suicide rates by firearms decreased over the study period, especially among aged 15 to 54 years and in rural and remote areas (Figure 2A and 2B); while suicide by hanging increased dramatically and reached a peak from 1996 to 2000, especially among aged 15-54 years (Figure 2A). For aged 55 and elder, suicide rate by hanging and firearms kept more stable than aged 54 and younger over the study period. Suicide rates by gases and vapours, solid and liquid substances slightly fluctuated in the study period among all population groups (Figure 2A and 2B). More details of suicide incidence trend over time in each population group and suicide methods were indicated in Supplemental 1 and 2. Poisson regression was implemented to examine the time series trend of suicide rates across population groups and by methods (Table 2). Suicide rates by sex, 55 years and over, in urban areas, and completed by firearms, solid and liquid substances had significantly decreased over time. However, suicide rates by hanging

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2 significantly increased. In this study, there were more decreased male suicide rate by firearms  
3 from period 1991-1995 to period 1996-2000 than other adjacent period (from period 1980-  
4 1990 to period 1991-1995, and from period 1996-2000 to period 2001-2005) as Table 3  
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24 Figure 3 indicates that among 15 to 34 years, north and central south of Northern Territory  
25 (NT), northeast and some southern parts of Western Australia (WA), northwest and central  
26 inland areas of Queensland (QLD) and some inland areas of New South Wales (NSW) had  
27 higher suicide mortalities (2A). The patterns were also similar for males (NT, QLD and WA  
28 in B1). Population aged between 35 and 74 had fewer high-risk areas than that aged 15 to 34  
29 (A2 and A3). For those aged 75 and over, mortalities in north and inland of QLD and a few  
30 LGAs in NSW and WA was higher than other areas; around 40% of total LGAs and  
31 unincorporated SLAs in NT and SA had no suicide occurred. Compared with males, more  
32 areas, e.g., northeast NT, most of rural/remote areas in WA and inland QLD, had no female  
33 suicide (2B). Rural and remote areas had lower rates by self-poison than urban areas, except  
34 for some LGAs in inland QLD, east SA and south WA (2C).  
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53 As suicide rates by firearms and by hanging had more significant changes over time than  
54 other methods and by population groups, we also explored whether this trend existed in  
55 spatial scales over time by cutting the whole study period into four 5-year periods (Figure 4).  
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3 Figure 4A indicates that suicide rate by hanging was low in the early years of study period  
4 (A1), and very few suicides occurred in rural and remote areas in WA, NT, QLD and NSW.  
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6 However, the suicide rate by hanging has increased in most areas of Australia since 1986.  
7  
8 North of WA, NT and SA, north of QLD and even urban LGAs had much higher suicide rates  
9  
10 between 1996 and 2005 compared with that in earlier years. Some areas (e.g., Mornington  
11  
12 Shire (MTS) of northwest of QLD, Bathurst-Melville (BM) of NT) had dramatic increase of  
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14 suicide by hanging. Both of them experienced increased number of suicide cases (especially  
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16 for suicide by hanging) between 1996 and 2005 (27 in MTS, 23 males and 26 by hanging; 23  
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18 in BM, 22 males and 20 by hanging), compared to that between 1986 and 1995 (4 in MTS,  
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20 male and 3 by hanging; 3 in BM, male and by hanging). Suicide rates by hanging in MTS  
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22 increased from 28.79 (1986-1995, annual average) to 236.32 per 100,000 (1996-2005, annual  
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24 average); and in BM increased from 14.10 (1986-1995, annual average) to 86.39 per 100,000  
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26 (1996-2005, annual average). However, the trend of suicide by firearms was opposite to that  
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28 of suicide by hanging (Figure 4B), especially in SA and NT, north and inland areas in NSW  
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30 and QLD, and middle of WA (B1 and B2). In general, unincorporated NT and SA had much  
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32 more suicide cases reported after 1996 (123 from 1996 to 2005) compared with the period  
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34 before 1996 (22 from 1986-1995).  
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41 Figure 4 about here  
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## 44 DISCUSSION

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47 This study explored suicide patterns in a range of different combinations of age, time,  
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49 method, and location in Australia, using both dynamic (trends over time) and static (averages  
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51 over the entire study period) approaches. Males accounted for most suicides. Suicide rate was  
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53 relatively higher among youths, young and middle-aged adults, in rural and remote areas, and  
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55 by hanging and by firearms. However, suicide rate among 55 years and over was higher than  
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3 population aged below 55 in the early years of the study period and then decreased  
4 significantly, especially for older males. Suicide by firearms decreased during the study  
5 period, while suicide by hanging kept increasing, especially in males and rural/remote areas.  
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7 The spatial and spatiotemporal patterns of suicide were consistent with yearly mean and  
8 temporal trends of suicide among different groups.  
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14 Elderly and upper middle-aged adults (55-years and over) usually have more loneliness and  
15 other health issues (e.g., chronic diseases) compared with the younger age population, which  
16 may lead to psychiatric symptoms, e.g., anxiety, sense of hopelessness and despair.<sup>22 23</sup> And  
17 usually older adults are less likely to seek psychiatric support when they have relevant  
18 symptoms, especially in earlier years (e.g., before the middle of 1990s).<sup>24</sup> Suicidal behaviours  
19 among older adults were attributed from psychiatric disorders among them, which were  
20 resulted from both of other health problems and reluctance for psychiatry support.<sup>22-24</sup> These  
21 may explain the higher annual average suicide rate among older adults than younger age  
22 groups in general, especially among males. However, suicide rate among this age group  
23 gradually decreased in the study period, especially after 2000, with an increased use of  
24 antidepressants among older adults.<sup>25</sup> Evidence also indicates that antidepressants can reduce  
25 psychological disorders, e.g., depression, and suicidal behaviours among the elderly,  
26 especially when combined with other interventions (e.g., counselling and family support).<sup>26</sup>  
27 Selective serotonin reuptake inhibitors have less side effects (e.g., cardiovascular impairs and  
28 drug interactions) than other drugs, and have been widely recommended to older adults from  
29 clinics.<sup>27 28</sup> Studies in other countries have also provided evidence about the protective effect  
30 of antidepressants on severe depression and suicide behaviours, although treatment of other  
31 levels of depression are still not clear.<sup>29 30</sup>  
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55 The rate of suicide rate by fire arms kept decreasing during the study period while suicide by  
56 hanging increased, especially among 54 years and younger. A study in Victoria indicated that  
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3 a decreased registration of firearms and lower suicide rates were significantly correlated from  
4  
5 1997 to 2000.<sup>31</sup> Before 1996, the importation of firearms was controlled by the  
6  
7 Commonwealth; and the sales and possession of firearms were regulated by states and  
8  
9 territories in Australia.<sup>32</sup> Some states had lag in progressing firearm control.<sup>33</sup> The Port Arthur  
10  
11 Massacre in Tasmania proposed Australia enacting The National Firearms Agreement in  
12  
13 1996, which regulates firearm sale, registration, storage and “bans on specific types of  
14  
15 firearms” nationally.<sup>34</sup> Our study found more decreased male suicide rate by firearms from  
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17 period 1991-1995 to period 1996-2000 than comparing other adjacent periods (e.g., period  
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19 1991-1995 compared with period 1986-1990). Thus it is suggestive that more strict firearm  
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21 law enforcement may have led to significant lower suicide rate by firearms over an extended  
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23 period at the national level after 1996.<sup>31</sup> However, other studies indicated that decreased  
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25 firearm suicide rate in young adults was accompanied with rising suicide rates by other  
26  
27 methods at the national and local level.<sup>35 36</sup> Our study also found this trend, especially among  
28  
29 males. Similarly, other countries experienced decreased suicide rate by firearms and increased  
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31 suicide rate by hanging over time.<sup>37 38</sup> This may due to increased substitute methods (e.g.,  
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33 hanging) for firearms, especially after 1996 when availability of firearms dropped in  
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35 Australia.<sup>39</sup> Thus those who seek violent methods for suicide may prefer using hanging rather  
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37 than firearms. Youths and middle-aged adults, which are less adaptable to social changes and  
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39 less exposed to firearms compared with older adults, are more likely to stop using firearms  
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41 after new law enforcement but relatively fragile to social and family difficulties.<sup>33</sup> Thus the  
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43 changes of patterns of suicide by firearms and hanging are more dynamic among youths and  
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45 middle-aged adults than older adults. Suicide rate by firearms in rural areas was higher than  
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47 that in urban areas, owing much to the availability of firearms. More evidence, including the  
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49 interaction between socio-economic changes and suicide methods, still needs to be assessed,  
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51 especially for recent years.  
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3 Only a small percentage of population and suicides were for those aged 75 and over, thus  
4 many LGAs had no suicides or higher suicide rate among older adults, especially in rural and  
5 remote areas. Usually areas with high risk of suicide have lower socio-economic status, along  
6 with higher proportion of Indigenous population.<sup>14</sup> Our previous study indicated that  
7 Mornington Shire in QLD and Bathurst-Melville in north of NT had much higher suicide risk,  
8 proportion of Indigenous population and lower socio-economic status than the national  
9 average, and both were indicated as high risk clusters using spatial cluster analysis (1999-  
10 2003).<sup>14</sup> Suicide by hanging has increased in Indigenous communities, as similar as other  
11 areas and population groups.<sup>38</sup> Alcohol has been introduced to the Aboriginal communities in  
12 Indigenous communities (e.g., Top North of NT and SA), and local people tended to be  
13 mentally and psychologically jeopardised by domestic violence and social disruptions related  
14 to alcohol use even from early years,<sup>40 41</sup> especially among youth and young adults.<sup>42</sup> Thus  
15 suicide behaviours were triggered from mental health problems after years of indirect  
16 influence from alcohol and can be spread quickly within an isolated community with limited  
17 population.<sup>43 44</sup> Family conflicts and social disruption have been reported contribution to the  
18 high suicide incidence in Indigenous population, e.g., lost of relatives in early lives due to a  
19 shorter life expectancy compared with non-Indigenous population, self-destructive and anti-  
20 social behaviours, unsolved anger and other life events.<sup>45</sup> Hanging acted as a substitute to  
21 other methods like firearms and poison, which may indicate that most Indigenous suicides  
22 were completed by hanging, especially after 1995.<sup>46</sup> Although Indigenous status of suicide  
23 was not available in this study, yet the results were consistent with previous studies. This  
24 mechanism may also explain the increased suicide cases in unincorporated areas in NT  
25 (including Bathurst-Melville) and SA in general over the study period.

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55 The differences of suicide reporting systems may also influence the results. For example,  
56 Williams et al reported that suicide rate in Queensland from the Queensland Suicide Register  
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3 (QSR) was higher than that from the Australian Bureau of Statistics (ABS), reasoning that the  
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5 disparity was due to such factors as information management and definition of suicidal  
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7 behaviours.<sup>47</sup> Thus the QLD suicide rate using ABS database was lower than using QSR  
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9 database, especially after 2000. However, ABS had a higher standard for evaluating the  
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11 causes of deaths, e.g., complete documents from hospital or police, which confirmed the  
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13 accuracy of information of current suicide database.<sup>48</sup> To keep the consistence of suicide data  
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15 reporting system across different states and accuracy of suicide database, we use ABS suicide  
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17 database in this study.  
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21 Recommendations on future research and public interventions can be proposed based on the  
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23 results of this study. Firstly, more details (e.g., health and financial status, alcohol and drugs  
24  
25 use, and family conflicts history) of suicide victims need to be acquired to help public health  
26  
27 policy makers and health workers to design and implement suicide control and prevention  
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29 strategies targeting particular population groups (e.g., male young adults) and areas (e.g.,  
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31 Indigenous communities). Suicide by firearms is still significant especially in rural and  
32  
33 remote areas. Thus effectiveness of control and prevention strategies e.g., firearm and  
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35 pesticide restrictions,<sup>49 50</sup> need to be evaluated. Gatekeeper education and training on rural  
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37 general practitioners are necessary in increasing their capacity of identifying local vulnerable  
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39 population and suicidal behaviours to reduce potential suicide risk. Education of primary  
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41 health workers and the general population are vital in reducing suicidal behaviours,<sup>51-54</sup> and  
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43 effectiveness of health education programs needs to be assessed locally. These activities  
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45 should be explored at a local level, especially in high risk areas and population groups, to  
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47 assess and improve the effectiveness of suicide prevention programs. Socioeconomic  
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49 variables (e.g., income and unemployment)<sup>55 56</sup> and environmental factors (e.g., temperature,  
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51 rainfall)<sup>57-59</sup> have associations with suicide over time periods. Thus the association of these  
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53 factors on suicide over spaces should also be addressed by time series analysis (e.g., in capital  
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3 cities which contains a certain number of suicide cases every month) and spatial modelling  
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5 analysis. As suicide is a complex issue, cross-sectional and multi-disciplinary approaches  
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7 need to be implemented in suicide control and prevention in different levels (e.g., national,  
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9 state and local). In conclusion, this study has explored patterns of suicide across population  
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11 groups and by suicide methods over time and space. These results may have significant  
12  
13 implication for developing national suicide prevention strategies through focusing on high  
14  
15 risk population groups, local areas and specific suicide methods.  
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### 18 19 **Contributorship statement**

20  
21 Xin Qi designed the study, implemented all statistical analyses and drafted the manuscript.  
22  
23 Shilu Tong conceptualised the idea and revised the study protocol, especially the research  
24  
25 design and data analysis. Wenbiao Hu provided advice on statistical analyses and  
26  
27 interpretation of the results. Andrew Page helped interpreting the results and drafting the  
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29 manuscript. All the authors contributed to the preparation of the final manuscript and  
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31 approved the submission.  
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### 35 36 **Competing interests**

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39 We declare that we have no competing interests.  
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50  
51 Monash University for his comments on the manuscript.  
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### 54 55 **Data sharing**

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57 No additional data available  
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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	15 to 34			Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio
	Cases	Rate	Rate Ratio (95% CI)			(95% CI)			(95% CI)			(95% CI)			(95% CI)
<b>By sex</b>															
Male	15,059	28.29	2.23 (2.19, 2.27)	12,672	25.61	2.02 (1.98, 2.06)	5,986	22.35	1.77 (1.72, 1.81)	2,091	30.98	2.45 (2.34, 2.56)	35,942	20.32	1.61 (1.58, 1.63)
Female	3,242	6.12	0.48 (0.47, 0.50)	3,556	7.14	0.56 (0.55, 0.58)	1,818	6.48	0.51 (0.49, 0.54)	682	6.14	0.49 (0.45, 0.52)	9,351	5.17	0.41 (0.40, 0.42)
<b>By region</b>															
Capital cities	11,267	16.28	1.29 (1.26, 1.31)	9,736	15.68	1.24 (1.21, 1.27)	4,568	14.21	1.12 (1.09, 1.16)	1,674	15.45	1.22 (1.16, 1.28)	27,332	12.32	0.97 (0.96, 0.99)
Regional centres	3,423	17.57	1.39 (1.34, 1.44)	3,269	17.72	1.40 (1.35, 1.45)	1,550	13.65	1.03 (1.03, 1.14)	584	15.96	1.26 (1.16, 1.37)	8,869	12.86	1.02 (1.00, 1.04)
Rural & remote areas	3,611	20.58	1.63 (1.57, 1.68)	3,223	17.23	1.36 (1.31, 1.41)	1,686	14.88	1.18 (1.12, 1.23)	515	15.37	1.21 (1.11, 1.32)	9,092	13.55	1.07 (1.05, 1.09)
<b>By methods</b>															
Firearms & other explosives	2,795	2.63	0.21 (0.20, 0.22)	2,285	2.30	0.18 (0.18, 0.19)	1,674	3.05	0.24 (0.23, 0.25)	556	3.11	0.25 (0.23, 0.27)	7,348	2.07	0.16 (0.16, 0.17)
Gases & vapours	3,457	3.25	0.26 (0.25, 0.27)	4,104	4.13	0.33 (0.32, 0.34)	1,277	2.33	0.18 (0.17, 0.20)	375	2.10	0.17 (0.15, 0.18)	9,214	2.60	0.20 (0.20, 0.21)
Hanging	7,366	6.93	0.55 (0.54, 0.56)	4,927	4.96	0.39 (0.38, 0.41)	2,301	4.20	0.33 (0.32, 0.35)	901	5.05	0.40 (0.37, 0.43)	15,620	4.40	0.35 (0.34, 0.35)
Solid or liquid substances	2,166	2.04	0.16 (0.16, 0.17)	2,863	2.88	0.23 (0.22, 0.24)	1,333	2.43	0.19 (0.18, 0.20)	434	2.43	0.19 (0.18, 0.21)	6,807	1.92	0.15 (0.15, 0.15)
Other	2,517	1.26	0.19 (0.18, 0.20)	2,049	2.06	0.16 (0.16, 0.17)	1,219	2.22	0.18 (0.17, 0.19)	507	2.84	0.23 (0.21, 0.25)	6,294	1.78	0.14 (0.14, 0.14)
<b>By region and by sex</b>															
<b>Male</b>															
Capital cities	9,072	26.66	2.08 (2.03, 2.13)	7,439	24.59	1.92 (1.87, 1.97)	3,358	21.86	1.71 (1.65, 1.77)	1,179	30.02	2.35 (2.22, 2.49)	21,107	19.63	1.53 (1.51, 1.56)
Regional centres	2,868	29.90	2.33 (2.25, 2.42)	2,593	28.60	2.23 (2.15, 2.32)	1,213	22.21	1.74 (1.64, 1.84)	468	32.80	2.57 (2.35, 2.81)	7,173	21.39	1.67 (1.63, 1.71)
Rural/remote areas	3,119	32.46	2.72 (2.62, 2.82)	2,640	25.99	2.16 (2.08, 2.24)	1,415	23.73	1.94 (1.84, 2.04)	444	31.82	2.60 (2.37, 2.85)	7,662	21.39	1.77 (1.73, 1.82)
<b>Female</b>															
Capital cities	2,195	6.40	0.50 (0.48, 0.52)	2,297	7.39	0.58 (0.55, 0.60)	1,210	7.33	0.57 (0.54, 0.61)	495	7.26	0.57 (0.52, 0.62)	6,225	5.58	0.44 (0.42, 0.45)
Regional centres	555	5.75	0.45 (0.42, 0.49)	676	7.37	0.58 (0.53, 0.62)	337	5.83	0.46 (0.41, 0.51)	116	5.27	0.41 (0.34, 0.50)	1,696	4.91	0.38 (0.37, 0.40)
Rural/remote areas	492	5.43	0.43 (0.39, 0.47)	583	6.12	0.51 (0.47, 0.55)	271	4.71	0.39 (0.34, 0.43)	71	3.41	0.28 (0.22, 0.35)	1,430	4.13	0.34 (0.33, 0.36)
<b>By methods and by region</b>															
<b>Capital cities</b>															
Firearms & other explosives	1,148	1.66	0.13 (0.12, 0.14)	913	1.47	0.12 (0.11, 0.12)	626	1.95	0.15 (0.14, 0.17)	211	1.95	0.16 (0.14, 0.18)	2,908	1.31	0.10 (0.10, 0.11)
Gases & vapours	2,299	3.32	0.26 (0.25, 0.27)	2,420	3.90	0.31 (0.30, 0.32)	732	2.28	0.18 (0.17, 0.19)	222	2.05	0.16 (0.14, 0.19)	5,674	2.56	0.20 (0.20, 0.21)
Hanging	4,339	6.27	0.50 (0.48, 0.51)	3,017	4.86	0.38 (0.37, 0.40)	1,470	4.57	0.36 (0.34, 0.38)	591	5.45	0.43 (0.40, 0.47)	9,478	4.27	0.30 (0.30, 0.31)
Solid or liquid substances	1,547	2.24	0.18 (0.17, 0.19)	1,864	3.00	0.24 (0.23, 0.25)	901	2.80	0.22 (0.21, 0.24)	284	2.62	0.21 (0.19, 0.23)	4,600	2.07	0.16 (0.16, 0.17)
Other	1,934	2.79	0.22 (0.21, 0.23)	1,522	2.45	0.19 (0.18, 0.20)	839	2.61	0.21 (0.19, 0.22)	366	3.38	0.27 (0.24, 0.30)	4,672	2.11	0.17 (0.16, 0.17)
<b>Regional centres</b>															
Firearms & other explosives	603	3.09	0.25 (0.23, 0.27)	495	2.68	0.21 (0.20, 0.23)	368	3.24	0.26 (0.23, 0.28)	131	3.58	0.28 (0.24, 0.33)	1,606	2.33	0.19 (0.18, 0.19)
Gases & vapours	631	3.24	0.26 (0.24, 0.28)	861	4.67	0.37 (0.35, 0.40)	275	2.42	0.19 (0.17, 0.22)	91	2.49	0.20 (0.16, 0.24)	1,858	2.70	0.21 (0.20, 0.22)
Hanging	1,502	7.71	0.61 (0.58, 0.64)	1,026	5.56	0.44 (0.41, 0.47)	456	4.02	0.32 (0.29, 0.35)	187	5.11	0.40 (0.35, 0.46)	3,200	4.65	0.37 (0.36, 0.38)
Solid or liquid substances	344	1.77	0.14 (0.13, 0.16)	570	3.09	0.25 (0.23, 0.27)	258	2.27	0.18 (0.16, 0.20)	92	2.51	0.20 (0.16, 0.24)	1,268	1.84	0.15 (0.14, 0.15)
Other	343	1.76	0.14 (0.13, 0.16)	317	1.72	0.14 (0.12, 0.15)	193	1.70	0.14 (0.12, 0.16)	83	2.27	0.18 (0.15, 0.22)	937	1.36	0.11 (0.10, 0.12)

Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005, continued)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
Rural/remote areas															
Firearms & other explosives	1,044	5.95	0.47 (0.44, 0.50)	877	4.69	0.37 (0.35, 0.40)	680	6.00	0.48 (0.44, 0.51)	214	6.39	0.51 (0.44, 0.52)	2,834	4.22	0.33 (0.32, 0.35)
Gases & vapours	527	3.00	0.24 (0.22, 0.26)	823	4.40	0.35 (0.33, 0.37)	270	2.38	0.19 (0.17, 0.21)	62	1.85	0.15 (0.11, 0.19)	1,682	2.51	0.20 (0.19, 0.21)
Hanging	1,525	8.69	0.69 (0.65, 0.72)	884	4.73	0.37 (0.35, 0.40)	375	3.31	0.26 (0.24, 0.29)	123	3.67	0.29 (0.24, 0.35)	2,942	4.38	0.35 (0.33, 0.36)
Solid or liquid substances	275	1.57	0.12 (0.11, 0.14)	429	2.29	0.18 (0.17, 0.20)	174	1.54	0.12 (0.11, 0.14)	58	1.73	0.14 (0.11, 0.18)	939	1.40	0.11 (0.10, 0.12)
Other	240	1.37	0.11 (0.10, 0.12)	210	1.12	0.09 (0.08, 0.10)	187	1.65	0.13 (0.11, 0.15)	58	1.73	0.14 (0.11, 0.18)	695	1.04	0.08 (0.08, 0.09)
<b>By methods and by sex</b>															
<b>Male</b>															
Firearms & other explosives	2,555	4.80	0.38 (0.37, 0.40)	2,123	4.29	0.34 (0.33, 0.36)	1,605	5.99	0.48 (0.45, 0.50)	551	8.16	0.65 (0.60, 0.70)	6,869	3.88	0.31 (0.30, 0.32)
Gases & vapours	2,961	5.56	0.44 (0.42, 0.46)	3,428	6.93	0.55 (0.53, 0.57)	1,091	4.07	0.32 (0.30, 0.34)	324	4.80	0.38 (0.34, 0.43)	7,805	4.41	0.35 (0.34, 0.36)
Hanging	6,267	11.77	0.93 (0.91, 0.96)	4,115	8.32	0.66 (0.64, 0.68)	1,821	6.80	0.54 (0.51, 0.56)	670	9.93	0.79 (0.73, 0.85)	12,963	7.33	0.58 (0.57, 0.59)
Solid or liquid substances	1,301	2.44	0.19 (0.18, 0.20)	1,573	3.18	0.25 (0.24, 0.27)	671	2.51	0.20 (0.18, 0.21)	198	2.93	0.23 (0.20, 0.27)	3,746	2.12	0.17 (0.16, 0.17)
Other	1,975	3.72	0.29 (0.28, 0.31)	1,433	2.89	0.23 (0.22, 0.24)	798	2.98	0.24 (0.22, 0.25)	348	5.16	0.41 (0.37, 0.46)	4,559	2.58	0.20 (0.20, 0.21)
<b>Female</b>															
Firearms & other explosives	240	0.45	0.04 (0.03, 0.04)	162	0.33	0.03 (0.02, 0.03)	69	0.25	0.02 (0.02, 0.03)	5	0.05	0.00 (0.00, 0.01)	479	0.26	0.02 (0.02, 0.02)
Gases & vapours	496	0.94	0.07 (0.07, 0.08)	676	1.36	0.11 (0.10, 0.12)	186	0.66	0.05 (0.05, 0.06)	51	0.46	0.04 (0.03, 0.05)	1,409	0.78	0.06 (0.06, 0.07)
Hanging	1,099	2.07	0.16 (0.15, 0.17)	812	1.63	0.12 (0.11, 0.13)	480	1.71	0.14 (0.12, 0.15)	231	2.08	0.17 (0.15, 0.19)	2,657	1.47	0.12 (0.11, 0.12)
Solid or liquid substances	865	1.63	0.13 (0.12, 0.14)	1,290	2.59	0.21 (0.19, 0.22)	662	2.36	0.19 (0.17, 0.20)	236	2.13	0.17 (0.15, 0.19)	3,061	1.69	0.13 (0.13, 0.14)
Other	542	1.03	0.08 (0.07, 0.09)	616	1.23	0.10 (0.09, 0.11)	421	1.50	0.12 (0.11, 0.13)	163	1.42	0.12 (0.10, 0.14)	1,745	0.97	0.08 (0.07, 0.08)
<b>Total suicide</b>	<b>18,301</b>	<b>17.23</b>	<b>1.36 (1.34, 1.38)</b>	<b>16,228</b>	<b>16.35</b>	<b>1.29 (1.27, 1.32)</b>	<b>7,804</b>	<b>14.23</b>	<b>1.12 (1.10, 1.15)</b>	<b>2,773</b>	<b>15.54</b>	<b>1.23 (1.18, 1.28)</b>	<b>45,293</b>	<b>12.66</b>	

Note: population size (all and by groups) was based on the mean value of Australian population census (1986, 1991, 1996, 2001, 2006). Reference group: annual average of total suicide in Australia between 1986 and 2005 after adjusting for population changes over years.

Table 2: Suicide rate change over time (population groups and suicide methods)

	RR	95% CI	P-value
All suicide	0.99	0.99, 0.99	<0.001
Male	0.99	0.99, 0.99	<0.001
Female	0.99	0.99, 0.99	<0.001
Age 15-34	0.99	0.99, 1.00	<0.001
Age 35-54	1.00	0.99, 1.00	0.009
Age 55-74	0.97	0.97, 0.98	<0.001
Age 75 & over	0.97	0.97, 0.98	<0.001
Urban areas	0.99	0.99, 0.99	0.001
Regional areas	1.00	0.99, 1.00	0.019
Rural & remote areas	1.00	0.99, 1.00	0.022
Firearm	0.93	0.93, 0.94	<0.001
Hanging	1.04	1.03, 1.04	<0.001
Gas and vapour	0.99	0.98, 0.99	<0.001
Solid or liquid substances	0.97	0.96, 0.97	<0.001
Other methods	0.98	0.98, 0.98	<0.001

RR: Relative Risk. Reference group: suicide in 1986 for each population group.

Table 3: Male suicide rate by firearms change over time (Reference: mean annual male suicide rate in 1986-1990 by each of age groups and types of regions)

Population group	Time period	RR	95% CI	P-value
15-34 yrs	2001-2005	0.22	0.08, 0.36	<0.001
	1996-2000	0.39	0.28, 0.51	<0.001
	1991-1995	0.78	0.69, 0.87	<0.001
35-54 yrs	2001-2005	0.39	0.26, 0.51	<0.001
	1996-2000	0.52	0.40, 0.64	<0.001
	1991-1995	0.83	0.72, 0.94	0.001
55-74 yrs	2001-2005	0.43	0.28, 0.57	<0.001
	1996-2000	0.63	0.49, 0.76	<0.001
	1991-1995	0.88	0.75, 1.01	0.049
75 yrs & over	2001-2005	0.45	0.21, 0.69	<0.001
	1996-2000	0.66	0.43, 0.89	<0.001
	1991-1995	0.83	0.59, 1.06	0.103
Capital cities	2001-2005	0.33	0.21, 0.45	<0.001
	1996-2000	0.46	0.35, 0.57	<0.001
	1991-1995	0.78	0.69, 0.88	<0.001
Regional centres	2001-2005	0.32	0.17, 0.48	<0.001
	1996-2000	0.47	0.33, 0.61	<0.001
	1991-1995	0.78	0.65, 0.90	<0.001
Rural and remote areas	2001-2005	0.41	0.29, 0.53	<0.001
	1996-2000	0.61	0.50, 0.72	<0.001
	1991-1995	0.91	0.81, 1.00	0.048

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2  
3 Figure 1: suicide rates over time and sub-groups (per 100,000)

4 A: Sex and age groups; B: Sex and urban rural differences; C: Sex and methods;

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7 Figure 2: suicide rates over time and methods (per 100,000, annual average)

8 A: Methods and age groups: B: Methods and urban rural difference

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11 Figure 3: Suicide rates among different groups across Australia (1986-2005)

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14 Figure 4: Suicide rates by self-harm over time and across space in Australia (1986-2005)

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19 Supplemental 1: Time trend of suicide rates by methods, sexes, age groups and urban/rural  
20 areas (part 1).

21 Supplemental 2: Time trend of suicide rates by methods, sexes, age groups and urban/rural  
22 areas (part 2).  
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# Dynamic pattern of suicide in Australia, 1986–2005

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## ABSTRACT

**Objective:** This study explored the spatiotemporal variations of suicide across Australia from 1986 to 2005, discussed the reasons for dynamic changes and recommended future suicide research and prevention strategies.

**Design:** Suicide (1986–2005) and population data were obtained from the Australian Bureau of Statistics. A series of analyses were conducted to examine the suicide pattern by sex, method and age group over time and space.

**Results:** Apparent differences in suicide rates across sex, age groups and suicide methods were found across different geographical areas. Male suicides were mainly completed by hanging, firearms, gases and poison. Female suicides were primarily completed by hanging and poison. **Suicide rates were high in rural areas than urban areas (capital cities and regional centres).** Suicide rate by firearms was higher in rural areas than urban areas, while the pattern for poison was opposite. Suicide rates slightly fluctuated for total population and aged between 15 and 54, while suicide decreased among 55 years and over during the study period. There was a decrease of suicide by firearms during the study period especially after 1996 when new firearm control law was implemented; while suicide by hanging kept increasing. **Some areas with a high proportion of Indigenous population (e.g., northwest of Queensland and top north of Northern Territory) had a high increase of suicide incidence after 1995.**

**Conclusions:** Suicide rates varied over time and space and across sexes, age groups, suicide methods. Suicide control and prevention strategies should target particular groups and areas of high and increased risk (e.g., Indigenous communities).

**Key words:** suicide, Australia, pattern

## STRENGTHS AND LIMITATIONS OF THE STUDY

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3 This study used various **cross-tabulations** with the 20-year Australian national suicide data cut  
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5 in different ways (e.g., population group, suicide methods, time and space), and provides  
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7 valuable information for examining suicide trends in Australia.  
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10 The different suicide rates across population groups and by suicide methods were presented,  
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12 which may help in designing effective suicide control and prevention programs. Different  
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14 levels of spatial scales (**Local Government Area (LGA) and Statistical Local Area (SLA)**)  
15  
16 were combined to best display the spatial distribution of suicide patterns; and the boundary  
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18 changes over years were also adjusted using advanced GIS methods.  
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21 This study only examined the suicide pattern at the population level using aggregated data.  
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23 Detailed individual information such as marriage, employment, Indigenous status and health  
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25 status before suicide was not available in the current dataset. Thus ecological fallacy in  
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27 inevitable in this study and **the results should be cautious when interpreted at the individual**  
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29 **level.**  
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33 The quality of suicide data may influence the results of the study. There is evidence  
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35 suggesting that some suicide deaths were not covered in the current ABS database. The real  
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37 suicide rate may be underestimated so the results should be interpreted with caution.  
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41 The suicide database was acquired a few years ago and may not indicate the trend of suicide  
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43 after 2005.  
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## 45 46 **INTRODUCTION**

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49 Suicide has long been regarded as a major public health issues globally, with about 1 million  
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51 suicide deaths annually.<sup>1</sup> Suicide patterns, including suicide methods, time and geographical  
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53 variation have been explored in many countries and regions, such as **Brazil,**<sup>2</sup> **China,**<sup>3</sup> **India,**<sup>4</sup>  
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55 **Russia,**<sup>5</sup> **Taiwan,**<sup>6</sup> **United Kingdom,**<sup>7</sup> and United States.<sup>8</sup> In Australia, suicide rates have  
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3 fluctuated since suicide registration started in the early of 1920s.<sup>9-11</sup> The trend of annual  
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5 suicide rate from 1980 to now was relatively stable (around 9 to 10 per 100,000) except for a  
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7 peak in 1997 (around 14.6 per 100,000).<sup>9-11</sup> However, there were still around 2,000 suicide  
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9 deaths annually, mainly in male adults (25-54 years age). Thus, it is vital to understand the  
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11 variations of suicide patterns over time, space, population groups (age, sex and ethnic groups)  
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13 and the possible reasons for these variations, in order to design effective suicide control and  
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15 prevention programs. Previous reports and studies have explored suicide patterns in Australia  
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17 over time,<sup>9-12</sup> methods<sup>13</sup> and space.<sup>14</sup> From geographical aspect, Australian Bureau of  
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19 Statistics (ABS) suicide reports covered a long period (1921 to 2010) and targeted at the state  
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21 level and capital cities.<sup>9-11</sup> However, suicide patterns at the smaller area (e.g., Local  
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23 Government Area, or LGA) level, especially in rural and remote areas, were not provided by  
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25 the ABS reports. The study by Cheung et al examined the spatial pattern of suicide in  
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27 Australia after 2000.<sup>15</sup> However, this study did not examine suicide pattern before 2000 or by  
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29 suicide methods; thus the dynamic spatial pattern of suicide and high risk areas of suicide by  
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31 particular method (e.g., firearms) could not be demonstrated. ABS reports indicated that most  
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33 suicide occur in urban areas in Australia, while less suicide were recorded in rural and remote  
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35 areas covering of most Australian land territory but with a lower population density. Thus it is  
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37 vital in selecting suitable spatial scales in examining spatial pattern of suicide in Australia.  
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39 The studies of spatial pattern of suicide in earlier years (e.g. before 1995) used relative large  
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41 spatial scales (e.g., Statistical Division rather than LGA), which may mask the spatial  
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43 variation of suicide in some rural areas (e.g., in Western Australia and Northern Territory) due  
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45 to their large size.<sup>16 17</sup> The spatial patterns of suicide by different population groups and  
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47 suicide methods over a long term covering both of previous years (e.g., before 2000) and  
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49 more recent years (after 2000) using suitable spatial scales (e.g., LGA) have not yet been  
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51 examined. The trends of suicide rates over time may differ across population groups (e.g.,  
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53 young or older adults) and areas (e.g., suicide by firearms in urban or rural areas). Thus, this  
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3 study examined long-term (both dynamic and static), spatiotemporal patterns of Australian  
4 national suicide, using a range of different combinations of age, time, method, and location  
5 from the period 1986-2005.  
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## 9 10 **DESIGN**

### 11 12 13 **Data source**

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16 The unit record data of suicide deaths between 1986 and 2005 were acquired from Australian  
17 Bureau of Statistics (ABS), including sex, International Classification of Disease (ICD) Code  
18 (ICD 9: 950.0-959.9; ICD 10: X60-X84)<sup>18 19</sup> relating to suicide or self-inflicted injury, age,  
19 country of birth, date of suicide and Statistical Local Area (SLA) code for place of suicide  
20 occurrence. The application of access to suicide database after 2005 is still under review by  
21 ABS. As SLA boundaries have changed dramatically over the study period, especially in  
22 urban areas, we chose Local Governmental Area (LGA) as the standard geographical unit to  
23 explore the spatial pattern of suicide. Choosing LGA as the spatial scale also aims to keep the  
24 balance of including a certain number of suicide in each geographical unit and avoiding using  
25 too large geographical unit. Each LGA is composed of one or more SLAs and the LGA  
26 boundaries are relatively stable over the study period. The Australian Standard Geographical  
27 Classification (ASGC), updated annually, was used to incorporate SLA codes into LGA  
28 codes, examine and adjust for SLA/LGA boundary changes over time. CDATA 2001, a  
29 product issued by ABS, provided digital boundaries and socio-demographic data of Australia  
30 (including 1991, 1996 and 2001 population census data at SLA/LGA levels, based on 2001  
31 Census boundary) and was applied in MapInfo 10.5 software package for map display.<sup>20</sup>  
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Population data (SLA/LGA levels) in 1986 and 2006 Census from ABS were merged with  
2001 Census data after adjustment for boundary changes using ASGC references. The suicide  
rates in different groups over time and across LGAs were then calculated. In this study, we

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3 categorize LGAs as three types: metropolitan areas of capital cities, regional centres (other  
4 LGA named as “city” outside of capital cities, e.g., City of Townville), rural and remote areas  
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6 (the remaining LGAs).  
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10 Most areas in South Australia (SA) and Northern Territory (NT) have a very low population  
11 density and were defined as unincorporated areas by ABS at the LGA level, but these areas  
12 were also composed of 27 SLAs according to the 2001 Census data. Thus we applied SLA  
13 data in unincorporated areas in SA and NT to provide more detailed information. In the 2001  
14 Census, Australia was divided into 628 LGAs, plus 27 SLAs in the unincorporated areas of  
15 SA and NT. Ethical approval was granted by the Human Research Ethics Committee,  
16 Queensland University of Technology.  
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### 25 26 **Statistical analyses** 27

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29 Descriptive and mapping approaches were applied to explore the age, sex, method, time and  
30 regional-specific patterns of suicide cases and rates. Firstly, we explored the basic pattern of  
31 suicide among different groups by calculating suicide rates, **Rate Ratio** and 95% Confident  
32 Interval (CI) to annual mean of national suicide rate over the study period **using the annual**  
33 **average suicide number in the whole Australia and population (1986-2005) as reference**  
34 **group**. Then the temporal trends of suicide rates in population groups were examined, using  
35 yearly data and Poisson regression. **Suicide in 1986 and by methods and population groups**  
36 **was the reference group and we used logarithm transferred population size in different years**  
37 **as an offset in Poisson regression. Suicide year was regarded as a covariate.** All the statistical  
38 analyses were implemented by SPSS 21.0.<sup>21</sup> Finally suicide rates at the LGA level were  
39 applied to display suicide rates over sexes, age groups and suicide methods using mapping  
40 approaches by MapInfo 10.5.<sup>20</sup> We used the annual average sex-specific rates for the whole of  
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3 Australia over the entire study period as the reference to calculate age-adjusted standardised  
4 mortality ratio (SMR) of both sexes which were mapped.  
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## 7 8 **RESULTS**

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10 This study included 45,293 suicide deaths in 20 years and only 187 suicides aged below 15,  
11 about 0.4% of total suicides. Thus we did not specifically analyse the pattern of suicide below  
12 15 years; however, we still keep them in results of all-age groups. Table 1 indicates that most  
13 of suicides occurred in those aged between 15 and 54 and occurred in capital cities and  
14 regional centres, as the majority of Australian population live in urban areas. However,  
15 suicide rate in rural and remote areas was higher than that in urban areas. Around 80% of  
16 suicides were males and most suicides aged between 15 and 54 years, while older males (75-  
17 year and over) had higher suicide rate than males in other age groups. Most suicides were in  
18 four methods: (1) firearms, air guns and other explosive (simplified as firearms, 16% of total  
19 suicides); (2) hanging (35% of total); (3) gases and vapours (20% of total); (4) solid or liquid  
20 substances (15% of total). The Odds Ratio (OR) and 95% Confident Interval (CI) of suicide in  
21 each population group and by different methods were calculated, using annual average suicide  
22 incidence in the study period in Australia as a reference (Table 1). We also applied Chi square  
23 test to check the suicide cases distribution by population groups and methods, and all the  
24 results are significant.  
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45 Table 1 about here

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48 Figure 1 shows the time-series trends of suicide by different groups. There was a peak of  
49 suicide rate among the total population from 1996 to 1998, particularly in males aged from 15  
50 to 34 years (A), males in rural and remote areas (B) and suicide completed by hanging (C). In  
51 the early years of the study period, suicide incidence among 55 years and over was higher  
52 than those below 55 years, however, it was observed to drop lower than that of young and  
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2 middle aged adults after 2000, particular in males (A). Suicide rate among 15 to 34 years had  
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4 peaks in 1997 and 1998 (especially for male at around 34 per 100,000 and total at around 21  
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6 per 100,000) and kept relatively steady in other years (14 to 17 per 100,000 for total and 25 to  
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8 28 per 100,000 for male) (A). In 1986, firearms and other explosives were the most common  
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10 methods of suicide in Australia, over 6 per 100,000 among males. However, the rate dropped  
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12 to around 2 per 100,000 in 2005. By contrast, male suicide rate by hanging rose from 3.8 per  
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14 100,000 in 1986 to 9.4 per 100,000 in 2005, after experiencing a peak of 10.6 per 100,000 in  
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16 1998 (C). Suicide rates by hanging in males dropped after 1997 but were still higher than the  
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18 early years of the study period. Figure 2 used 5-year periods to explore suicide of specific  
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20 methods by age groups and urban rural differences for a better visual effect. Suicide rates by  
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22 firearms decreased over the study period, especially among aged 15 to 54 years and in rural  
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24 and remote areas (Figure 2A and 2B); while suicide by hanging increased dramatically and  
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26 reached a peak from 1996 to 2000, especially among aged 15-54 years (Figure 2A). For aged  
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28 55 and elder, suicide rate by hanging and firearms kept more stable than aged 54 and younger  
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30 over the study period. Suicide rates by gases and vapours, solid and liquid substances slightly  
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32 fluctuated in the study period among all population groups (Figure 2A and 2B). More details  
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34 of suicide incidence trend over time in each population group and suicide methods were  
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36 indicated in Supplemental 1 and 2. Poisson regression was implemented to examine the time  
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38 series trend of suicide rates across population groups and by methods (Table 2). Suicide rates  
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40 by sex, 55 years and over, in urban areas, and completed by firearms, solid and liquid  
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42 substances had significantly decreased over time. However, suicide rates by hanging  
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44 significantly increased. In this study, there were more decreased male suicide rate by firearms  
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46 from period 1991-1995 to period 1996-2000 than other adjacent period (from period 1980-  
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48 1990 to period 1991-1995, and from period 1996-2000 to period 2001-2005) as Table 3  
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50 indicated.  
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15 Figure 3 indicates that among 15 to 34 years, north and central south of Northern Territory  
16 (NT), northeast and some southern parts of Western Australia (WA), northwest and central  
17 inland areas of Queensland (QLD) and some inland areas of New South Wales (NSW) had  
18 higher suicide mortalities (2A). The patterns were also similar for males (NT, QLD and WA  
19 in B1). Population aged between 35 and 74 had fewer high-risk areas than that aged 15 to 34  
20 (A2 and A3). For those aged 75 and over, mortalities in north and inland of QLD and a few  
21 LGAs in NSW and WA was higher than other areas; around 40% of total LGAs and  
22 unincorporated SLAs in NT and SA had no suicide occurred. Compared with males, more  
23 areas, e.g., northeast NT, most of rural/remote areas in WA and inland QLD, had no female  
24 suicide (2B). Rural and remote areas had lower rates by self-poison than urban areas, except  
25 for some LGAs in inland QLD, east SA and south WA (2C).  
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40 Figure 3 about here  
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43 As suicide rates by firearms and by hanging had more significant changes over time than  
44 other methods and by population groups, we also explored whether this trend existed in  
45 spatial scales over time by cutting the whole study period into four 5-year periods (Figure 4).  
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47 Figure 4A indicates that suicide rate by hanging was low in the early years of study period  
48 (A1), and very few suicides occurred in rural and remote areas in WA, NT, QLD and NSW.  
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50 However, the **suicide rate by hanging has increased in most areas of Australia since 1986.**  
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52 North of WA, NT and SA, north of QLD and even urban LGAs had much higher suicide rates  
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3 between 1996 and 2005 compared with that in earlier years. Some areas (e.g., Mornington  
4 Shire (MTS) of northwest of QLD, Bathurst-Melville (BM) of NT) had dramatic increase of  
5 suicide by hanging. Both of them experienced increased number of suicide cases (especially  
6 for suicide by hanging) between 1996 and 2005 (27 in MTS, 23 males and 26 by hanging; 23  
7 in BM, 22 males and 20 by hanging), compared to that between 1986 and 1995 (4 in MTS,  
8 male and 3 by hanging; 3 in BM, male and by hanging). Suicide rates by hanging in MTS  
9 increased from 28.79 (1986-1995, annual average) to 236.32 per 100,000 (1996-2005, annual  
10 average); and in BM increased from 14.10 (1986-1995, annual average) to 86.39 per 100,000  
11 (1996-2005, annual average). However, the trend of suicide by firearms was opposite to that  
12 of suicide by hanging (Figure 4B), especially in SA and NT, north and inland areas in NSW  
13 and QLD, and middle of WA (B1 and B2). In general, unincorporated NT and SA had much  
14 more suicide cases reported after 1996 (123 from 1996 to 2005) compared with the period  
15 before 1996 (22 from 1986-1995).

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## 35 DISCUSSION

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37 This study explored suicide patterns in a range of different combinations of age, time,  
38 method, and location in Australia, using both dynamic (trends over time) and static (averages  
39 over the entire study period) approaches. Males accounted for most suicides. Suicide rate was  
40 relatively higher among youths, young and middle-aged adults, in rural and remote areas, and  
41 by hanging and by firearms. However, suicide rate among 55 years and over was higher than  
42 population aged below 55 in the early years of the study period and then decreased  
43 significantly, especially for older males. Suicide by firearms decreased during the study  
44 period, while suicide by hanging kept increasing, especially in males and rural/remote areas.  
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3 The spatial and spatiotemporal patterns of suicide were consistent with yearly mean and  
4 temporal trends of suicide among different groups.  
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8 Elderly and upper middle-aged adults (55-years and over) usually have more loneliness and  
9 other health issues (e.g., chronic diseases) compared with the younger age population, which  
10 may lead to psychiatric symptoms, e.g., anxiety, sense of hopelessness and despair.<sup>22 23</sup> And  
11 usually older adults are less likely to seek psychiatric support when they have relevant  
12 symptoms, especially in earlier years (e.g., before the middle of 1990s).<sup>24</sup> Suicidal behaviours  
13 among older adults were attributed from psychiatric disorders among them, which were  
14 resulted from both of other health problems and reluctance for psychiatry support.<sup>22-24</sup> These  
15 may explain the higher annual average suicide rate among older adults than younger age  
16 groups in general, especially among males. However, suicide rate among this age group  
17 gradually decreased in the study period, especially after 2000, with an increased use of  
18 antidepressants among older adults.<sup>25</sup> Evidence also indicates that antidepressants can reduce  
19 psychological disorders, e.g., depression, and suicidal behaviours among the elderly,  
20 especially when combined with other interventions (e.g., counselling and family support).<sup>26</sup>  
21 Selective serotonin reuptake inhibitors have less side effects (e.g., cardiovascular impairs and  
22 drug interactions) than other drugs, and have been widely recommended to older adults from  
23 clinics.<sup>27 28</sup> Studies in other countries have also provided evidence about the protective effect  
24 of antidepressants on severe depression and suicide behaviours, although treatment of other  
25 levels of depression are still not clear.<sup>29 30</sup>  
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48 The rate of suicide rate by fire arms kept decreasing during the study period while suicide by  
49 hanging increased, especially among 54 years and younger. A study in Victoria indicated that  
50 a decreased registration of firearms and lower suicide rates were significantly correlated from  
51 1997 to 2000.<sup>31</sup> Before 1996, the importation of firearms was controlled by the  
52 Commonwealth; and the sales and possession of firearms were regulated by states and  
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3 territories in Australia.<sup>32</sup> Some states had lag in progressing firearm control.<sup>33</sup> The Port Arthur  
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5 Massacre in Tasmania proposed Australia enacting The National Firearms Agreement in  
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7 1996, which regulates firearm sale, registration, storage and “bans on specific types of  
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9 firearms” nationally.<sup>34</sup> Our study found more decreased male suicide rate by firearms from  
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11 period 1991-1995 to period 1996-2000 than comparing other adjacent periods (e.g., period  
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13 1991-1995 compared with period 1986-1990). Thus it is suggestive that more strict firearm  
14  
15 law enforcement may have led to significant lower suicide rate by firearms over an extended  
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17 period at the national level after 1996.<sup>31</sup> However, other studies indicated that decreased  
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19 firearm suicide rate in young adults was accompanied with rising suicide rates by other  
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21 methods at the national and local level.<sup>35 36</sup> Our study also found this trend, especially among  
22  
23 males. Similarly, other countries experienced decreased suicide rate by firearms and increased  
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25 suicide rate by hanging over time.<sup>37 38</sup> This may due to increased substitute methods (e.g.,  
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27 hanging) for firearms, especially after 1996 when availability of firearms dropped in  
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29 Australia.<sup>39</sup> Thus those who seek violent methods for suicide may prefer using hanging rather  
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31 than firearms. Youths and middle-aged adults, which are less adaptable to social changes and  
32  
33 less exposed to firearms compared with older adults, are more likely to stop using firearms  
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35 after new law enforcement but relatively fragile to social and family difficulties.<sup>33</sup> Thus the  
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37 changes of patterns of suicide by firearms and hanging are more dynamic among youths and  
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39 middle-aged adults than older adults. Suicide rate by firearms in rural areas was higher than  
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41 that in urban areas, owing much to the availability of firearms. More evidence, including the  
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43 interaction between socio-economic changes and suicide methods, still needs to be assessed,  
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45 especially for recent years.

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52 Only a small percentage of population and suicides were for those aged 75 and over, thus  
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54 many LGAs had no suicides or higher suicide rate among older adults, especially in rural and  
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56 remote areas. Usually areas with high risk of suicide have lower socio-economic status, along  
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3 with higher proportion of Indigenous population.<sup>14</sup> Our previous study indicated that  
4 Mornington Shire in QLD and Bathurst-Melville in north of NT had much higher suicide risk,  
5 proportion of Indigenous population and lower socio-economic status than the national  
6 average, and both were indicated as high risk clusters using spatial cluster analysis (1999-  
7 2003).<sup>14</sup> Suicide by hanging has increased in Indigenous communities, as similar as other  
8 areas and population groups.<sup>38</sup> Alcohol has been introduced to the Aboriginal communities in  
9 Indigenous communities (e.g., Top North of NT and SA), and local people tended to be  
10 mentally and psychologically jeopardised by domestic violence and social disruptions related  
11 to alcohol use even from early years,<sup>40 41</sup> especially among youth and young adults.<sup>42</sup> Thus  
12 suicide behaviours were triggered from mental health problems after years of indirect  
13 influence from alcohol and can be spread quickly within an isolated community with limited  
14 population.<sup>43 44</sup> Family conflicts and social disruption have been reported contribution to the  
15 high suicide incidence in Indigenous population, e.g., lost of relatives in early lives due to a  
16 shorter life expectancy compared with non-Indigenous population, self-destructive and anti-  
17 social behaviours, unsolved anger and other life events.<sup>45</sup> Hanging acted as a substitute to  
18 other methods like firearms and poison, which may indicate that most Indigenous suicides  
19 were completed by hanging, especially after 1995.<sup>46</sup> Although Indigenous status of suicide  
20 was not available in this study, yet the results were consistent with previous studies. This  
21 mechanism may also explain the increased suicide cases in unincorporated areas in NT  
22 (including Bathurst-Melville) and SA in general over the study period.

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48 The differences of suicide reporting systems may also influence the results. For example,  
49 Williams et al reported that suicide rate in Queensland from the Queensland Suicide Register  
50 (QSR) was higher than that from the Australian Bureau of Statistics (ABS), reasoning that the  
51 disparity was due to such factors as information management and definition of suicidal  
52 behaviours.<sup>47</sup> Thus the QLD suicide rate using ABS database was lower than using QSR  
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3 database, especially after 2000. However, ABS had a higher standard for evaluating the  
4 causes of deaths, e.g., complete documents from hospital or police, which confirmed the  
5 accuracy of information of current suicide database.<sup>48</sup> To keep the consistence of suicide data  
6 reporting system across different states and accuracy of suicide database, we use ABS suicide  
7 database in this study.  
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14 Recommendations on future research and public interventions can be proposed based on the  
15 results of this study. Firstly, more details (e.g., health and financial status, alcohol and drugs  
16 use, and family conflicts history) of suicide victims need to be acquired to help public health  
17 policy makers and health workers to design and implement suicide control and prevention  
18 strategies targeting particular population groups (e.g., male young adults) and areas (e.g.,  
19 Indigenous communities). Suicide by firearms is still significant especially in rural and  
20 remote areas. Thus effectiveness of control and prevention strategies e.g., firearm and  
21 pesticide restrictions,<sup>49 50</sup> need to be evaluated. Gatekeeper education and training on rural  
22 general practitioners are necessary in increasing their capacity of identifying local vulnerable  
23 population and suicidal behaviours to reduce potential suicide risk. Education of primary  
24 health workers and the general population are vital in reducing suicidal behaviours,<sup>51-54</sup> and  
25 effectiveness of health education programs needs to be assessed locally. These activities  
26 should be explored at a local level, especially in high risk areas and population groups, to  
27 assess and improve the effectiveness of suicide prevention programs. Socioeconomic  
28 variables (e.g., income and unemployment)<sup>55 56</sup> and environmental factors (e.g., temperature,  
29 rainfall)<sup>57-59</sup> have associations with suicide over time periods. Thus the association of these  
30 factors on suicide over spaces should also be addressed by time series analysis (e.g., in capital  
31 cities which contains a certain number of suicide cases every month) and spatial modelling  
32 analysis. As suicide is a complex issue, cross-sectional and multi-disciplinary approaches  
33 need to be implemented in suicide control and prevention in different levels (e.g., national,  
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3 state and local). In conclusion, this study has explored patterns of suicide across population  
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5 groups and by suicide methods over time and space. These results may have significant  
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7 implication for developing national suicide prevention strategies through focusing on high  
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9 risk population groups, local areas and specific suicide methods.  
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### 11 12 **Contributorship statement**

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15 Xin Qi designed the study, implemented all statistical analyses and drafted the manuscript.  
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17 Shilu Tong conceptualised the idea and revised the study protocol, especially the research  
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19 design and data analysis. Wenbiao Hu provided advice on statistical analyses and  
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21 interpretation of the results. Andrew Page helped interpreting the results and drafting the  
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23 manuscript. All the authors contributed to the preparation of the final manuscript and  
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25 approved the submission.  
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### 28 29 **Competing interests**

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32 We declare that we have no competing interests.  
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41  
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43  
44 Monash University for his comments on the manuscript.  
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### 47 48 **Data sharing**

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50 No additional data available  
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19 Figure 1: suicide rates over time and sub-groups (per 100,000)

20 A: Sex and age groups; B: Sex and urban rural differences; C: Sex and methods;

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23 Figure 2: suicide rates over time and methods (per 100,000, annual average)

24 A: Methods and age groups; B: Methods and urban rural difference

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27 Figure 3: Suicide rates among different groups across Australia (1986-2005)

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30 Figure 4: Suicide rates by self-harm over time and across space in Australia (1986-2005)

Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	15 to 34			Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio	Cases	Rate	Rate Ratio
	Cases	Rate	Rate Ratio (95% CI)			(95% CI)			(95% CI)			(95% CI)			(95% CI)
<b>By sex</b>															
Male	15,059	28.29	2.23 (2.19, 2.27)	12,672	25.61	2.02 (1.98, 2.06)	5,986	22.35	1.77 (1.72, 1.81)	2,091	30.98	2.45 (2.34, 2.56)	35,942	20.32	1.61 (1.58, 1.63)
Female	3,242	6.12	0.48 (0.47, 0.50)	3,556	7.14	0.56 (0.55, 0.58)	1,818	6.48	0.51 (0.49, 0.54)	682	6.14	0.49 (0.45, 0.52)	9,351	5.17	0.41 (0.40, 0.42)
<b>By region</b>															
Capital cities	11,267	16.28	1.29 (1.26, 1.31)	9,736	15.68	1.24 (1.21, 1.27)	4,568	14.21	1.12 (1.09, 1.16)	1,674	15.45	1.22 (1.16, 1.28)	27,332	12.32	0.97 (0.96, 0.99)
Regional centres	3,423	17.57	1.39 (1.34, 1.44)	3,269	17.72	1.40 (1.35, 1.45)	1,550	13.65	1.03 (1.03, 1.14)	584	15.96	1.26 (1.16, 1.37)	8,869	12.86	1.02 (1.00, 1.04)
Rural & remote areas	3,611	20.58	1.63 (1.57, 1.68)	3,223	17.23	1.36 (1.31, 1.41)	1,686	14.88	1.18 (1.12, 1.23)	515	15.37	1.21 (1.11, 1.32)	9,092	13.55	1.07 (1.05, 1.09)
<b>By methods</b>															
Firearms & other explosives	2,795	2.63	0.21 (0.20, 0.22)	2,285	2.30	0.18 (0.18, 0.19)	1,674	3.05	0.24 (0.23, 0.25)	556	3.11	0.25 (0.23, 0.27)	7,348	2.07	0.16 (0.16, 0.17)
Gases & vapours	3,457	3.25	0.26 (0.25, 0.27)	4,104	4.13	0.33 (0.32, 0.34)	1,277	2.33	0.18 (0.17, 0.20)	375	2.10	0.17 (0.15, 0.18)	9,214	2.60	0.20 (0.20, 0.21)
Hanging	7,366	6.93	0.55 (0.54, 0.56)	4,927	4.96	0.39 (0.38, 0.41)	2,301	4.20	0.33 (0.32, 0.35)	901	5.05	0.40 (0.37, 0.43)	15,620	4.40	0.35 (0.34, 0.35)
Solid or liquid substances	2,166	2.04	0.16 (0.16, 0.17)	2,863	2.88	0.23 (0.22, 0.24)	1,333	2.43	0.19 (0.18, 0.20)	434	2.43	0.19 (0.18, 0.21)	6,807	1.92	0.15 (0.15, 0.15)
Other	2,517	1.26	0.19 (0.18, 0.20)	2,049	2.06	0.16 (0.16, 0.17)	1,219	2.22	0.18 (0.17, 0.19)	507	2.84	0.23 (0.21, 0.25)	6,294	1.78	0.14 (0.14, 0.14)
<b>By region and by sex</b>															
<b>Male</b>															
Capital cities	9,072	26.66	2.08 (2.03, 2.13)	7,439	24.59	1.92 (1.87, 1.97)	3,358	21.86	1.71 (1.65, 1.77)	1,179	30.02	2.35 (2.22, 2.49)	21,107	19.63	1.53 (1.51, 1.56)
Regional centres	2,868	29.90	2.33 (2.25, 2.42)	2,593	28.60	2.23 (2.15, 2.32)	1,213	22.21	1.74 (1.64, 1.84)	468	32.80	2.57 (2.35, 2.81)	7,173	21.39	1.67 (1.63, 1.71)
Rural/remote areas	3,119	32.46	2.72 (2.62, 2.82)	2,640	25.99	2.16 (2.08, 2.24)	1,415	23.73	1.94 (1.84, 2.04)	444	31.82	2.60 (2.37, 2.85)	7,662	21.39	1.77 (1.73, 1.82)
<b>Female</b>															
Capital cities	2,195	6.40	0.50 (0.48, 0.52)	2,297	7.39	0.58 (0.55, 0.60)	1,210	7.33	0.57 (0.54, 0.61)	495	7.26	0.57 (0.52, 0.62)	6,225	5.58	0.44 (0.42, 0.45)
Regional centres	555	5.75	0.45 (0.42, 0.49)	676	7.37	0.58 (0.53, 0.62)	337	5.83	0.46 (0.41, 0.51)	116	5.27	0.41 (0.34, 0.50)	1,696	4.91	0.38 (0.37, 0.40)
Rural/remote areas	492	5.43	0.43 (0.39, 0.47)	583	6.12	0.51 (0.47, 0.55)	271	4.71	0.39 (0.34, 0.43)	71	3.41	0.28 (0.22, 0.35)	1,430	4.13	0.34 (0.33, 0.36)
<b>By methods and by region</b>															
<b>Capital cities</b>															
Firearms & other explosives	1,148	1.66	0.13 (0.12, 0.14)	913	1.47	0.12 (0.11, 0.12)	626	1.95	0.15 (0.14, 0.17)	211	1.95	0.16 (0.14, 0.18)	2,908	1.31	0.10 (0.10, 0.11)
Gases & vapours	2,299	3.32	0.26 (0.25, 0.27)	2,420	3.90	0.31 (0.30, 0.32)	732	2.28	0.18 (0.17, 0.19)	222	2.05	0.16 (0.14, 0.19)	5,674	2.56	0.20 (0.20, 0.21)
Hanging	4,339	6.27	0.50 (0.48, 0.51)	3,017	4.86	0.38 (0.37, 0.40)	1,470	4.57	0.36 (0.34, 0.38)	591	5.45	0.43 (0.40, 0.47)	9,478	4.27	0.30 (0.30, 0.31)
Solid or liquid substances	1,547	2.24	0.18 (0.17, 0.19)	1,864	3.00	0.24 (0.23, 0.25)	901	2.80	0.22 (0.21, 0.24)	284	2.62	0.21 (0.19, 0.23)	4,600	2.07	0.16 (0.16, 0.17)
Other	1,934	2.79	0.22 (0.21, 0.23)	1,522	2.45	0.19 (0.18, 0.20)	839	2.61	0.21 (0.19, 0.22)	366	3.38	0.27 (0.24, 0.30)	4,672	2.11	0.17 (0.16, 0.17)
<b>Regional centres</b>															
Firearms & other explosives	603	3.09	0.25 (0.23, 0.27)	495	2.68	0.21 (0.20, 0.23)	368	3.24	0.26 (0.23, 0.28)	131	3.58	0.28 (0.24, 0.33)	1,606	2.33	0.19 (0.18, 0.19)
Gases & vapours	631	3.24	0.26 (0.24, 0.28)	861	4.67	0.37 (0.35, 0.40)	275	2.42	0.19 (0.17, 0.22)	91	2.49	0.20 (0.16, 0.24)	1,858	2.70	0.21 (0.20, 0.22)
Hanging	1,502	7.71	0.61 (0.58, 0.64)	1,026	5.56	0.44 (0.41, 0.47)	456	4.02	0.32 (0.29, 0.35)	187	5.11	0.40 (0.35, 0.46)	3,200	4.65	0.37 (0.36, 0.38)
Solid or liquid substances	344	1.77	0.14 (0.13, 0.16)	570	3.09	0.25 (0.23, 0.27)	258	2.27	0.18 (0.16, 0.20)	92	2.51	0.20 (0.16, 0.24)	1,268	1.84	0.15 (0.14, 0.15)
Other	343	1.76	0.14 (0.13, 0.16)	317	1.72	0.14 (0.12, 0.15)	193	1.70	0.14 (0.12, 0.16)	83	2.27	0.18 (0.15, 0.22)	937	1.36	0.11 (0.10, 0.12)

Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005, continued)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
Rural/remote areas															
Firearms & other explosives	1,044	5.95	0.47 (0.44, 0.50)	877	4.69	0.37 (0.35, 0.40)	680	6.00	0.48 (0.44, 0.51)	214	6.39	0.51 (0.44, 0.52)	2,834	4.22	0.33 (0.32, 0.35)
Gases & vapours	527	3.00	0.24 (0.22, 0.26)	823	4.40	0.35 (0.33, 0.37)	270	2.38	0.19 (0.17, 0.21)	62	1.85	0.15 (0.11, 0.19)	1,682	2.51	0.20 (0.19, 0.21)
Hanging	1,525	8.69	0.69 (0.65, 0.72)	884	4.73	0.37 (0.35, 0.40)	375	3.31	0.26 (0.24, 0.29)	123	3.67	0.29 (0.24, 0.35)	2,942	4.38	0.35 (0.33, 0.36)
Solid or liquid substances	275	1.57	0.12 (0.11, 0.14)	429	2.29	0.18 (0.17, 0.20)	174	1.54	0.12 (0.11, 0.14)	58	1.73	0.14 (0.11, 0.18)	939	1.40	0.11 (0.10, 0.12)
Other	240	1.37	0.11 (0.10, 0.12)	210	1.12	0.09 (0.08, 0.10)	187	1.65	0.13 (0.11, 0.15)	58	1.73	0.14 (0.11, 0.18)	695	1.04	0.08 (0.08, 0.09)
<b>By methods and by sex</b>															
Male															
Firearms & other explosives	2,555	4.80	0.38 (0.37, 0.40)	2,123	4.29	0.34 (0.33, 0.36)	1,605	5.99	0.48 (0.45, 0.50)	551	8.16	0.65 (0.60, 0.70)	6,869	3.88	0.31 (0.30, 0.32)
Gases & vapours	2,961	5.56	0.44 (0.42, 0.46)	3,428	6.93	0.55 (0.53, 0.57)	1,091	4.07	0.32 (0.30, 0.34)	324	4.80	0.38 (0.34, 0.43)	7,805	4.41	0.35 (0.34, 0.36)
Hanging	6,267	11.77	0.93 (0.91, 0.96)	4,115	8.32	0.66 (0.64, 0.68)	1,821	6.80	0.54 (0.51, 0.56)	670	9.93	0.79 (0.73, 0.85)	12,963	7.33	0.58 (0.57, 0.59)
Solid or liquid substances	1,301	2.44	0.19 (0.18, 0.20)	1,573	3.18	0.25 (0.24, 0.27)	671	2.51	0.20 (0.18, 0.21)	198	2.93	0.23 (0.20, 0.27)	3,746	2.12	0.17 (0.16, 0.17)
Other	1,975	3.72	0.29 (0.28, 0.31)	1,433	2.89	0.23 (0.22, 0.24)	798	2.98	0.24 (0.22, 0.25)	348	5.16	0.41 (0.37, 0.46)	4,559	2.58	0.20 (0.20, 0.21)
Female															
Firearms & other explosives	240	0.45	0.04 (0.03, 0.04)	162	0.33	0.03 (0.02, 0.03)	69	0.25	0.02 (0.02, 0.03)	5	0.05	0.00 (0.00, 0.01)	479	0.26	0.02 (0.02, 0.02)
Gases & vapours	496	0.94	0.07 (0.07, 0.08)	676	1.36	0.11 (0.10, 0.12)	186	0.66	0.05 (0.05, 0.06)	51	0.46	0.04 (0.03, 0.05)	1,409	0.78	0.06 (0.06, 0.07)
Hanging	1,099	2.07	0.16 (0.15, 0.17)	812	1.63	0.12 (0.11, 0.13)	480	1.71	0.14 (0.12, 0.15)	231	2.08	0.17 (0.15, 0.19)	2,657	1.47	0.12 (0.11, 0.12)
Solid or liquid substances	865	1.63	0.13 (0.12, 0.14)	1,290	2.59	0.21 (0.19, 0.22)	662	2.36	0.19 (0.17, 0.20)	236	2.13	0.17 (0.15, 0.19)	3,061	1.69	0.13 (0.13, 0.14)
Other	542	1.03	0.08 (0.07, 0.09)	616	1.23	0.10 (0.09, 0.11)	421	1.50	0.12 (0.11, 0.13)	163	1.42	0.12 (0.10, 0.14)	1,745	0.97	0.08 (0.07, 0.08)
<b>Total suicide</b>	<b>18,301</b>	<b>17.23</b>	<b>1.36 (1.34, 1.38)</b>	<b>16,228</b>	<b>16.35</b>	<b>1.29 (1.27, 1.32)</b>	<b>7,804</b>	<b>14.23</b>	<b>1.12 (1.10, 1.15)</b>	<b>2,773</b>	<b>15.54</b>	<b>1.23 (1.18, 1.28)</b>	<b>45,293</b>	<b>12.66</b>	

Note: population size (all and by groups) was based on the mean value of Australian population census (1986, 1991, 1996, 2001, 2006). Reference group: annual average of total suicide in Australia between 1986 and 2005 after adjusting for population changes over years.

Table 2: Suicide rate change over time (population groups and suicide methods)

	RR	95% CI	P-value
All suicide	0.99	0.99, 0.99	<0.001
Male	0.99	0.99, 0.99	<0.001
Female	0.99	0.99, 0.99	<0.001
Age 15-34	0.99	0.99, 1.00	<0.001
Age 35-54	1.00	0.99, 1.00	0.009
Age 55-74	0.97	0.97, 0.98	<0.001
Age 75 & over	0.97	0.97, 0.98	<0.001
Urban areas	0.99	0.99, 0.99	0.001
Regional areas	1.00	0.99, 1.00	0.019
Rural & remote areas	1.00	0.99, 1.00	0.022
Firearm	0.93	0.93, 0.94	<0.001
Hanging	1.04	1.03, 1.04	<0.001
Gas and vapour	0.99	0.98, 0.99	<0.001
Solid or liquid substances	0.97	0.96, 0.97	<0.001
Other methods	0.98	0.98, 0.98	<0.001

RR: Relative Risk. Reference group: suicide in 1986 for each population group.



Table 3: Male suicide rate by firearms change over time (Reference: mean annual male suicide rate in 1986-1990 by each of age groups and types of regions)

Population group	Time period	RR	95% CI	P-value
15-34 yrs	2001-2005	0.22	0.08, 0.36	<0.001
	1996-2000	0.39	0.28, 0.51	<0.001
	1991-1995	0.78	0.69, 0.87	<0.001
35-54 yrs	2001-2005	0.39	0.26, 0.51	<0.001
	1996-2000	0.52	0.40, 0.64	<0.001
	1991-1995	0.83	0.72, 0.94	0.001
55-74 yrs	2001-2005	0.43	0.28, 0.57	<0.001
	1996-2000	0.63	0.49, 0.76	<0.001
	1991-1995	0.88	0.75, 1.01	0.049
75 yrs & over	2001-2005	0.45	0.21, 0.69	<0.001
	1996-2000	0.66	0.43, 0.89	<0.001
	1991-1995	0.83	0.59, 1.06	0.103
Capital cities	2001-2005	0.33	0.21, 0.45	<0.001
	1996-2000	0.46	0.35, 0.57	<0.001
	1991-1995	0.78	0.69, 0.88	<0.001
Regional centres	2001-2005	0.32	0.17, 0.48	<0.001
	1996-2000	0.47	0.33, 0.61	<0.001
	1991-1995	0.78	0.65, 0.90	<0.001
Rural and remote areas	2001-2005	0.41	0.29, 0.53	<0.001
	1996-2000	0.61	0.50, 0.72	<0.001
	1991-1995	0.91	0.81, 1.00	0.048

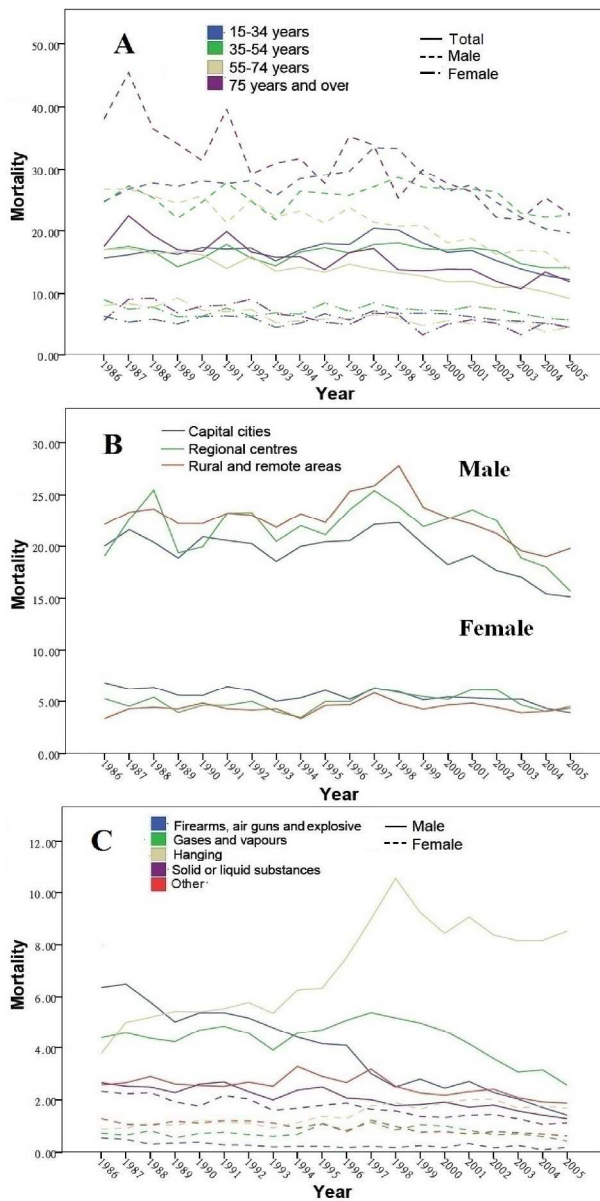
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Supplemental 1: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 1).

Supplemental 2: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 2).

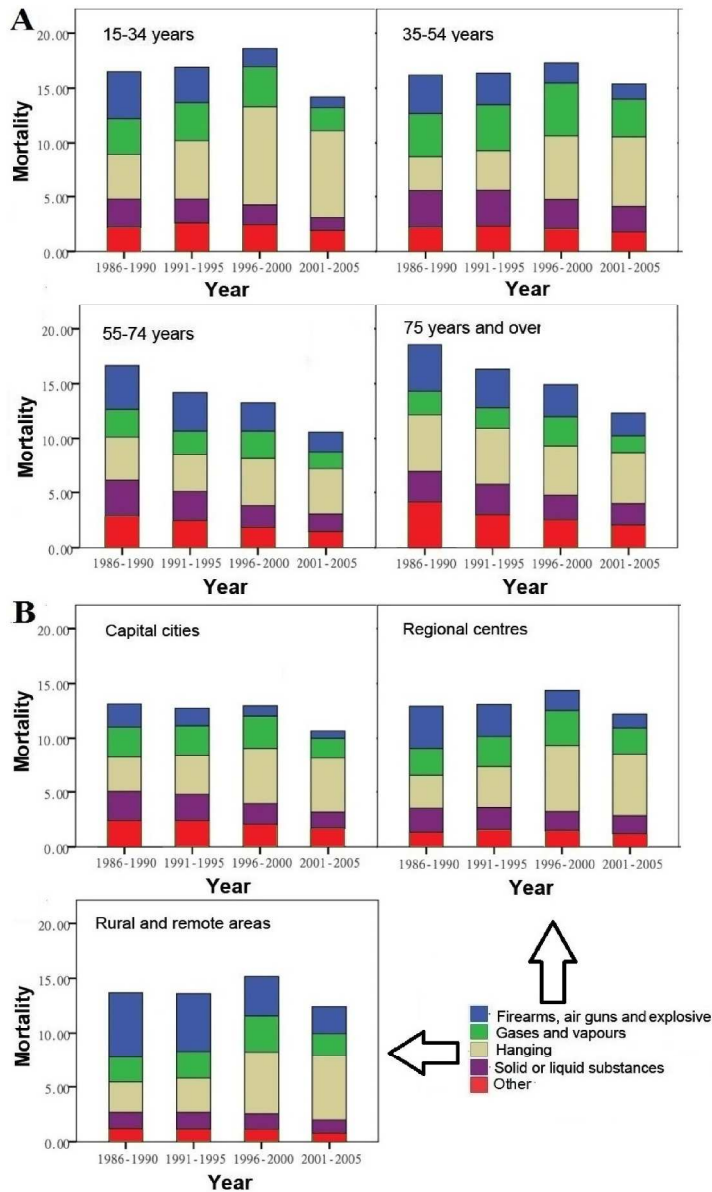
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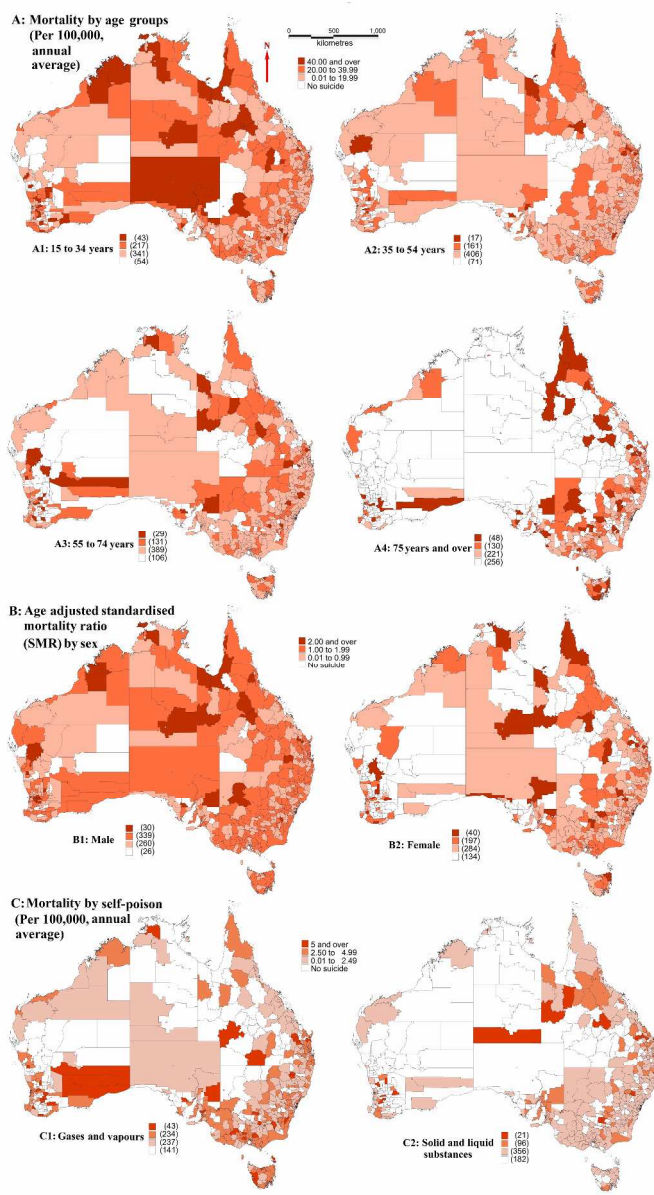
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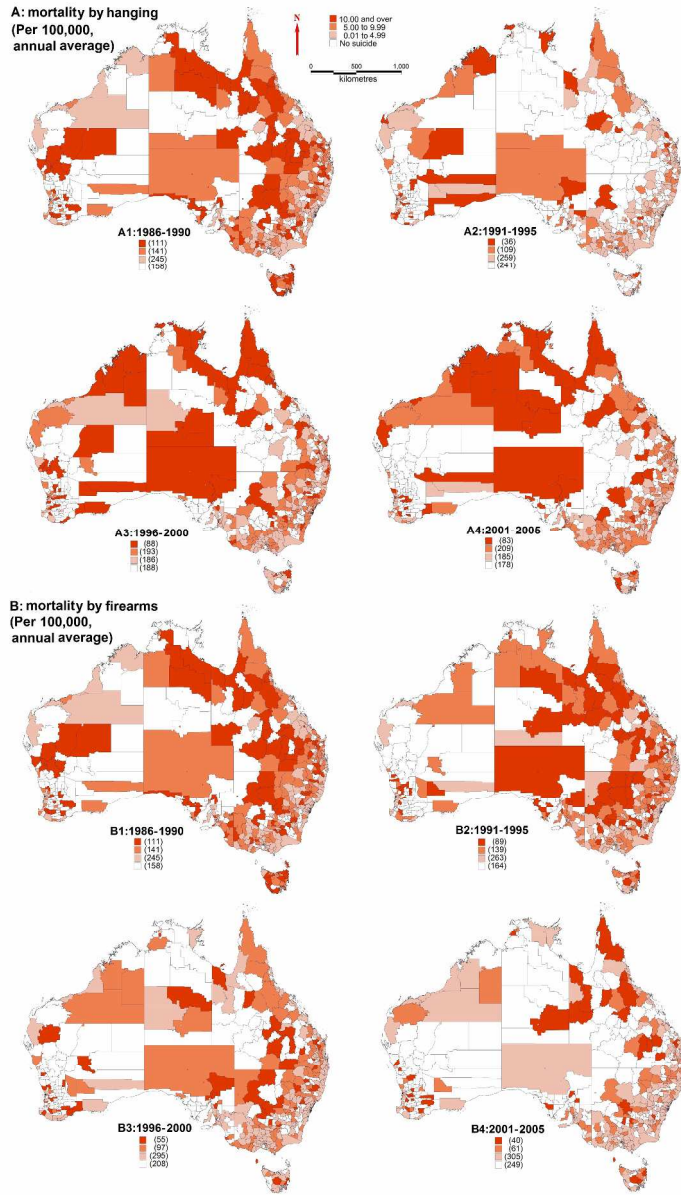
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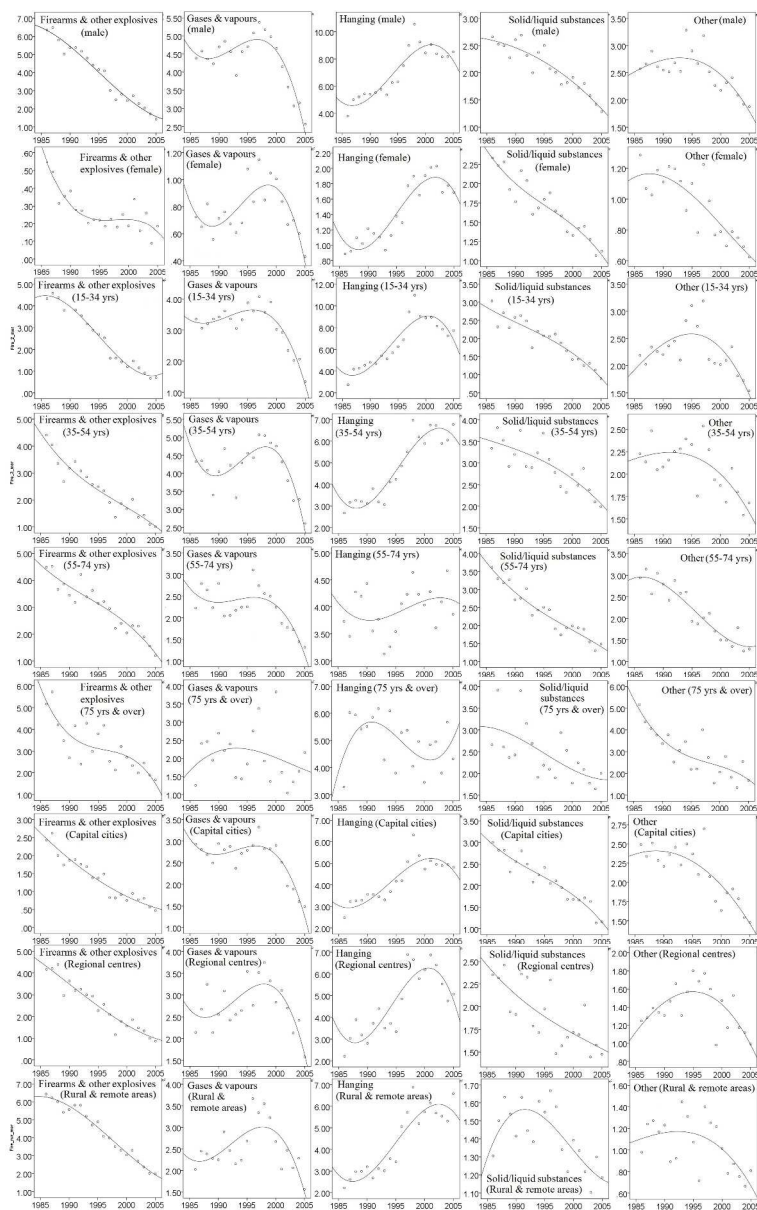
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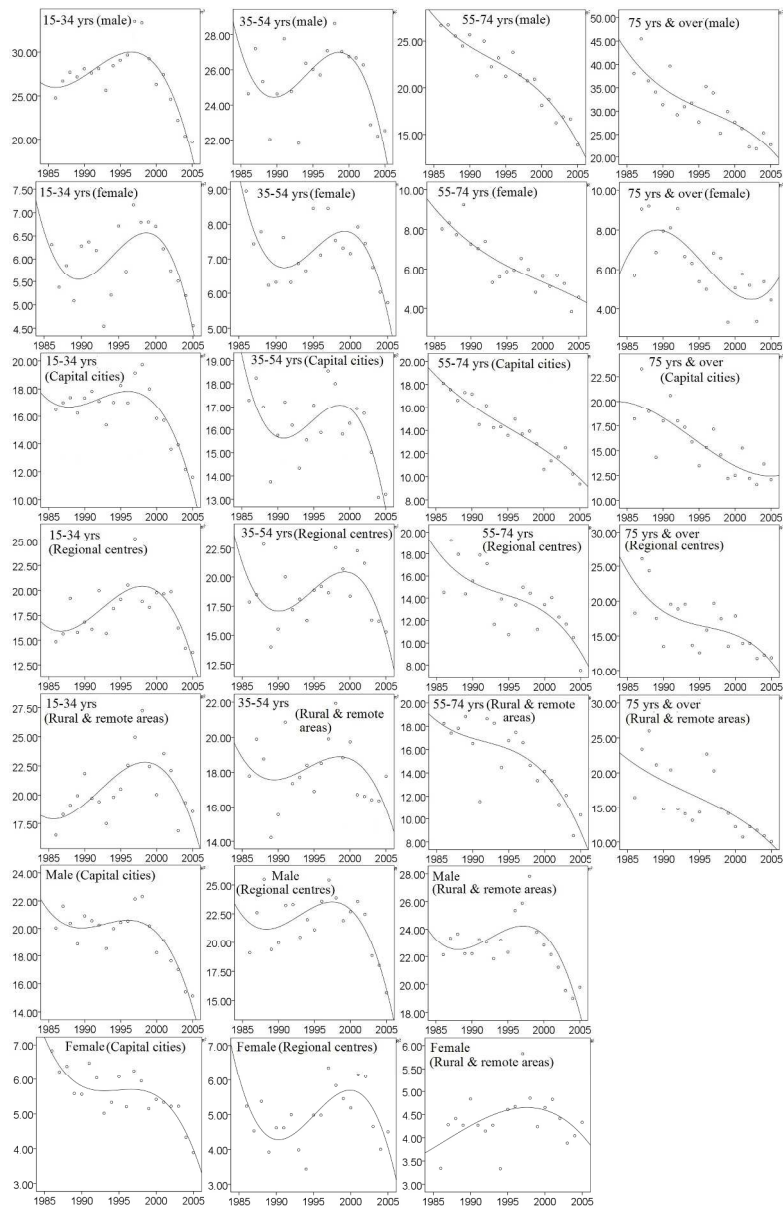
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# BMJ Open

## Dynamic pattern of suicide in Australia, 1986–2005, a descriptive-analytic study

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Keywords:	Australia, Suicide, Pattern

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# Dynamic pattern of suicide in Australia, 1986–2005, a descriptive-analytic study

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## ABSTRACT

**Objective:** This study explores the spatiotemporal variations of suicide across Australia from 1986 to 2005, discusses the reasons for dynamic changes, and considers future suicide research and prevention strategies.

**Design:** Suicide (1986–2005) and population data were obtained from the Australian Bureau of Statistics. A series of analyses were conducted to examine the suicide pattern by sex, method and age group over time and geography.

**Results:** Differences in suicide rates across sex, age groups and suicide methods were found across geographical areas. Male suicides were mainly completed by hanging, firearms, gases and self-poisoning. Female suicides were primarily completed by hanging and self-poisoning. Suicide rates were higher in rural areas than urban areas (capital cities and regional centres). Suicide rates by firearms were higher in rural areas than urban areas, while the pattern for self-poisoning showed the reverse. Suicide rates did not fluctuate substantially for the total population and those aged between 15 and 54, while suicide decreased among 55 years and over during the study period. There was a decrease of suicide by firearms during the study period especially after 1996 when new firearm control law was implemented; while suicide by hanging kept continued to increase. Areas with a high proportion of Indigenous population (e.g., northwest of Queensland and top north of Northern Territory) had showed a substantial increase in suicide incidence after 1995.

**Conclusions:** Suicide rates varied over time and space and across sexes, age groups, suicide methods. This study provides detailed patterns of suicide to inform suicide control and prevention strategies for specific sub-groups and areas of high and increased risk.

**Key words:** suicide, Australia, pattern

## STRENGTHS AND LIMITATIONS OF THE STUDY

Different levels of spatial scale were combined to display spatial distribution of suicide patterns; with boundary changes over the period adjusted using advanced GIS methods.

Aggregate data was used. Detailed individual information was not available.

Quality of suicide data may vary over time.

The suicide database may not indicate the trends of suicide after 2005.

## INTRODUCTION

Suicide remains a major public health issue globally, with about 1 million suicide deaths annually.<sup>1</sup> Suicide patterns, including suicide methods, time and geographical variation have been explored in many countries and regions, such as Brazil,<sup>2</sup> China,<sup>3</sup> India,<sup>4</sup> Russia,<sup>5</sup> Taiwan,<sup>6</sup> United Kingdom,<sup>7</sup> and United States.<sup>8</sup> In Australia, suicide rates have fluctuated since suicide registration started in the early of 1920s.<sup>9-11</sup> The trend of annual suicide rates from 1980 was relatively stable (around 9 to 10 per 100,000) except for a peak in 1997 (around 14.6 per 100,000).<sup>9-11</sup> However, there were still approximately 2,000 suicide deaths

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3 annually, mainly in male adults (25-54 years age). Thus, it is vital to understand the variations  
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5 of suicide patterns over time, space, population groups (age, sex and ethnic groups) and the  
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7 possible reasons for these variations, in order to design effective suicide control and  
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9 prevention programs. Previous reports and studies have explored suicide patterns in Australia  
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11 over time,<sup>9-12</sup> methods<sup>13</sup> and space.<sup>14</sup> From a geographical perspective, the Australian Bureau  
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13 of Statistics (ABS) suicide reports covered a long period (1921 to 2010) presented at state and  
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15 capital city level.<sup>9-11</sup> However, suicide patterns at the smaller area (e.g., Local Government  
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17 Area, or LGA) level, especially in rural and remote areas, were not routinely provided in ABS  
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19 reports. A study by Cheung et al examined the spatial pattern of suicide in Australia after  
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21 2000.<sup>15</sup> However, this study did not examine suicide pattern before 2000 or by suicide  
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23 methods; thus the dynamic spatial pattern of suicide and high risk areas of suicide by  
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25 particular method (e.g., firearms) could not be demonstrated. ABS reports indicated that most  
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27 suicide occur in urban areas in Australia, while fewer suicides were recorded in rural and  
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29 remote areas, areas of lower population density. It is therefore important to select suitable  
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31 spatial scales in examining the geographic pattern of suicide in Australia. The studies of  
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33 spatial patterns of suicide in earlier years (e.g. before 1995) used relative large spatial scales  
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35 (e.g., Statistical Division rather than LGA), which may mask the spatial variation of suicide in  
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37 some rural areas (e.g., in Western Australia and Northern Territory) due to their large  
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39 geographic size.<sup>16 17</sup> The spatial patterns of suicide by different population groups and suicide  
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41 methods over the long term covering both earlier years (e.g., before 2000) and more recent  
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43 years (after 2000) using suitable spatial scales (e.g., LGA) have not yet been examined.  
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45 Trends in suicide rates over time are likely to differ across population groups (e.g., young or  
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47 older adults) and area (e.g., suicide by firearms in urban or rural areas). Thus, this study  
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49 examined long-term (both dynamic and static), spatiotemporal patterns of Australian national  
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51 suicide, using a range of different combinations of age, time, method, and location from the  
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53 period 1986-2005.  
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## DESIGN

### Data source

Unit record data of suicide deaths between 1986 and 2005 were obtained from the Australian Bureau of Statistics (ABS), including sex, International Classification of Disease (ICD) Code (ICD 9: 950.0-959.9; ICD 10: X60-X84)<sup>18 19</sup> relating to suicide or self-inflicted injury, age, country of birth, date of suicide and Statistical Local Area (SLA) code for place of suicide occurrence. Access to unit record suicide for these variables from the ABS after 2005 was not possible, as the related procedure is under review. As SLA boundaries have changed dramatically over the study period, especially in urban areas, we chose Local Governmental Area (LGA) as the standard geographical unit to explore the spatial pattern of suicide. Choosing LGA as the spatial scale also aims to keep the balance between including sufficient case numbers of suicide in each geographical unit and using too large a geographical unit. Each LGA is composed of one or more SLAs, and LGA boundaries are relatively stable over the study period. The Australian Standard Geographical Classification (ASGC), updated annually, was used to incorporate SLA codes into LGA codes, examine and adjust for SLA/LGA boundary changes over time. CDATA 2001, a product issued by ABS, provided digital boundaries and socio-demographic data of Australia (including 1991, 1996 and 2001 population census data at SLA/LGA levels, based on 2001 Census boundary) and was applied in MapInfo 10.5 software package for map display.<sup>20</sup> Population data (SLA/LGA levels) in 1986 and 2006 Censuses from ABS were merged with 2001 Census data after adjustment for boundary changes using ASGC references. The suicide rates in different groups over time and across LGAs were then calculated. In this study, we categorized LGAs as: metropolitan areas of capital cities, regional centres (other LGA named as “city” outside of capital cities, e.g., City of Townville), or rural and remote areas (remaining LGAs).

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3 Most areas in South Australia (SA) and Northern Territory (NT) have a very low population  
4 density and were defined as unincorporated areas by ABS at the LGA level. However, these  
5 areas were also composed of 27 SLAs according to the 2001 Census data. Thus we applied  
6 SLA data in unincorporated areas in SA and NT to provide more detailed geographic  
7 information. In the 2001 Census, Australia was divided into 628 LGAs, plus 27 SLAs in the  
8 unincorporated areas of SA and NT. Ethical approval was granted by the Human Research  
9 Ethics Committee, Queensland University of Technology.  
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### 19 **Statistical analyses**

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22 Descriptive and mapping approaches were applied to explore the age, sex, method, time and  
23 regional-specific patterns of suicide cases and rates. Firstly, we explored the basic pattern of  
24 suicide among different groups by calculating suicide rates, Rate Ratios and 95% Confidence  
25 Interval (CI) to the annual mean national suicide rate over the study period using the annual  
26 average suicide number in the whole Australian population (1986-2005) as reference group.  
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28 Temporal trends of suicide rates in population groups were then examined, using yearly data  
29 and Poisson regression, offset by the natural logarithm of the population size and adjusting for  
30 year as a covariate. All the statistical analyses were implemented by SPSS 21.0.<sup>21</sup> Finally  
31 suicide rates at the LGA level were applied to display suicide rates by sex, age group and  
32 method using mapping approaches by MapInfo 10.5.<sup>20</sup> We used the annual average sex-  
33 specific rates for the whole of Australia over the entire study period as the reference to  
34 calculate age-adjusted standardised mortality ratios (SMRs) for both sexes.  
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### 49 **RESULTS**

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52 This study included 45,293 suicide deaths for the 20 year period. Table 1 indicates that most  
53 suicides occurred in those aged between 15 and 54 and occurred in capital cities and regional  
54 centres, as the majority of Australian population live in urban areas. However, suicide rates in  
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2 rural and remote areas were higher than in urban areas. Approximately 80% of suicides were  
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4 males, with the majority of suicides occurring in those aged between 15 and 54 years,  
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6 although older males (75-year and over) had higher suicide rates than males in other age  
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8 groups. Four methods accounted for the majority of suicides: (1) firearms, air guns and other  
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10 explosives (simplified as firearms, 16% of total suicides); (2) hanging (35% of total); (3)  
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12 gases and vapours (20% of total); (4) solid or liquid substances (15% of total). The Rate Ratio  
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14 and 95% Confident Interval (CI) of suicide in each population group and by different methods  
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16 were calculated, using annual average suicide incidence in the study period in Australia as a  
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18 reference (Table 1). We also applied Chi square test to assess the distribution of suicide cases  
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20 by population groups and method (all differences were statistically significant).  
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25  
26 Table 1 about here  
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29 Figure 1 shows time-series trends by different groups. There was a peak in the suicide rate  
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31 among the total population during the period 1996 to 1998, particularly in males aged from 15  
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33 to 34 years (A), males in rural and remote areas (B) and suicide completed by hanging (C). In  
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35 the early years of the study period, suicide incidence among 55 years and over was higher  
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37 than those below 55 years, however, rates decreased over time and were lower than those of  
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39 young and middle aged adults after 2000, particular in males (A). Suicide rates among 15 to  
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41 34 years had peaks in 1997 and 1998 (especially for males peaking at approximately 34 per  
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43 100,000 and at approximately 21 per 100,000 for total suicide rates) and kept relatively steady  
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45 in other years (25 to 28 per 100,000 for males and 14 to 17 per 100,000 for the total  
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47 population) (A). In 1986, firearms and other explosives were the most common methods of  
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49 suicide in Australia (over 6 per 100,000 among males). However, the rate dropped to around 2  
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51 per 100,000 in 2005. By contrast, male suicide rates by hanging rose from 3.8 per 100,000 in  
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53 1986 to 9.4 per 100,000 in 2005, after experiencing a peak of 10.6 per 100,000 in 1998 (C).  
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55 Suicide rates by hanging in males dropped after 1997 but were still higher than the early years  
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3 of the study period. Figure 2 used 5-year periods to explore method-specific suicide by age  
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5 groups and urban rural differences. Suicide rates by firearms decreased over the study period,  
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7 especially among those aged 15 to 54 years and in rural and remote areas (Figure 2A and 2B);  
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9 while suicide by hanging increased dramatically and reached a peak during 1996 to 2000,  
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11 especially among aged 15-54 years (Figure 2A). For those aged 55 and older, suicide rates by  
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13 hanging and firearms remained more stable than for those aged 54 and younger over the study  
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15 period. Suicide rates by gases and vapours, solid and liquid substances fluctuated over the  
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17 study period among all population groups (Figure 2A and 2B). Further detailed stratification  
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19 of suicide incidence trends over time in each population group and suicide methods are  
20  
21 presented in Supplemental 1 and 2. Poisson regression was implemented to examine the time  
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23 series trend of suicide rates across population groups and by methods (Table 2). Suicide rates  
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25 by sex, 55 years and over, urban residence, and suicide by firearms, solid and liquid  
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27 substances decreased over time. However, suicide rates by hanging significantly increased.  
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29 Table 3 indicated that male suicide rates by firearms kept decreasing across the whole study  
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31 period, especially from period 1991-1995 to period 1996-2000.  
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37 Figure 1 about here

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39 Figure 2 about here

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49 Figure 3 shows that among 15 to 34 years, the north and central south areas of the Northern  
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51 Territory (NT), the northeast and some southern parts of Western Australia (WA), the  
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53 northwest and central inland areas of Queensland (QLD) and some inland areas of New South  
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55 Wales (NSW) had higher suicide (2A). The patterns were also similar for males (NT, QLD  
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57 and WA in B1). Those aged between 35 and 74 had fewer high-risk areas than those aged 15  
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3 to 34 (A2 and A3). For those aged 75 and over, suicide in northern and inland QLD and a  
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5 small number of LGAs in NSW and WA were higher than other areas. Around 40% of total  
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7 LGAs and unincorporated SLAs in NT and SA had no suicide data. Compared with males, a  
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9 greater number of areas had no female suicide data (2B). Rural and remote areas had lower  
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11 rates by self-poisoning than urban areas, except for some LGAs in inland QLD, east SA and  
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13 south WA (2C).  
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17 Figure 3 about here  
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20 As suicide rates by firearms and by hanging had more significant changes over time than  
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22 other methods and by population groups, we also explored whether this trend existed in  
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24 spatial scales over time by stratifying the whole study period into four 5-year periods (Figure  
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26 4). Figure 4A shows that suicide rates by hanging was low in the early years of study period  
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28 (A1), and very few suicides occurred in rural and remote areas in WA, NT, QLD and NSW.  
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30 However, the suicide rate by hanging increased in most areas of Australia since 1986. North  
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32 of WA, NT and SA, north of QLD and even urban LGAs had much higher suicide rates  
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34 between 1996 and 2005 compared with rates in earlier years. Some areas (e.g., Mornington  
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36 Shire (MTS) of northwest QLD, Bathurst-Melville (BM) of NT) had dramatic increases in  
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38 suicide by hanging. Both of these areas experienced an increase in the number of suicide  
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40 cases (especially for suicide by hanging) between 1996 and 2005 (27 in MTS, 23 males and  
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42 26 by hanging; 23 in BM, 22 males and 20 by hanging), compared to the period between 1986  
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44 and 1995 (4 in MTS, male and 3 by hanging; 3 in BM, male and by hanging). Suicide rates by  
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46 hanging in MTS increased from 28.79 (1986-1995, annual average) to 236.32 per 100,000  
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48 (1996-2005, annual average); and in BM increased from 14.10 (1986-1995, annual average)  
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50 to 86.39 per 100,000 (1996-2005, annual average). However, the trend of suicide by firearms  
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52 was opposite to that of suicide by hanging (Figure 4B), especially in SA and NT, north and  
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54 inland areas in NSW and QLD, and middle of WA (B1 and B2). In general, unincorporated  
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3 NT and SA had a greater number of suicide cases after 1996 (123 from 1996 to 2005)  
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5 compared with the period before 1996 (22 from 1986-1995).  
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8 Figure 4 about here  
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## 10 **DISCUSSION**

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14 This study explored suicide patterns for a range of different combinations of age, time,  
15 method, and location in Australia, using both dynamic (trends over time) and static (averages  
16 over the entire study period) approaches. Males accounted for most suicides, and the suicide  
17 rate was higher among young and middle-aged adults, in rural and remote areas, more  
18 commonly by hanging and by firearms. Suicide rate among those aged 55 years and over  
19 declined substantially over the study period, especially for males. Suicide by firearms  
20 decreased during the study period, while suicide by hanging kept increasing, especially in  
21 males and rural and remote areas. The spatial and spatiotemporal patterns of suicide were  
22 consistent with yearly mean and temporal trends of suicide among different groups.  
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35 Elderly and upper middle-aged adults (55-years and over) usually have more loneliness and  
36 other health issues (e.g., chronic diseases) compared with the younger age population, which  
37 may lead to psychiatric symptoms, e.g., anxiety, sense of hopelessness and despair.<sup>22 23</sup> And  
38 older adults may be less likely to seek psychiatric support when they have relevant symptoms,  
39 especially in earlier years (e.g., before the middle of 1990s).<sup>24</sup> However, suicide rates among  
40 this age group gradually decreased in the study period, especially after 2000, occurring  
41 contemporaneously with an increased use of antidepressants among older adults.<sup>25</sup>  
42 Antidepressants can reduce psychological disorders, e.g., depression, and suicidal behaviours  
43 among the elderly, especially when combined with other interventions (e.g., counselling and  
44 family support).<sup>26</sup> Selective serotonin reuptake inhibitors have less side effects (e.g.,  
45 cardiovascular impairment and drug interactions) than other drugs, and have been widely  
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2 recommended to older adults from clinics.<sup>27 28</sup> Studies in other countries have also provided  
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4 evidence about the protective effect of antidepressants on severe depression and suicidal  
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6 behaviour, although treatment of other levels of depression are still not clear.<sup>29 30</sup>  
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10 Suicide rates by firearms decreased over the study period while suicide by hanging increased,  
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12 especially among 54 years and younger. A study in Victoria indicated that a decreased  
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14 registration of firearms and lower suicide rates were significantly correlated from 1997 to  
15  
16 2000.<sup>31</sup> Before 1996, the importation of firearms was controlled by the Commonwealth; and  
17  
18 the sales and possession of firearms were regulated by states and territories in Australia.<sup>32</sup>  
19  
20 Some states had lag in progressing firearm control.<sup>33</sup> The Port Arthur Massacre in Tasmania  
21  
22 led to the enactment of The National Firearms Agreement in 1996, regulating firearm sales,  
23  
24 registration, storage and bans on specific types of firearms nationally.<sup>34</sup> Our study found a  
25  
26 sharper decline in male suicide rates by firearms from the period 1991-1995 to the period  
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28 1996-2000 than for earlier periods (e.g., period 1991-1995 compared with period 1986-1990),  
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30 suggestive of a sustained impact of the firearm law enforcement after 1996.<sup>31</sup> Other studies  
31  
32 have suggested that decreased firearm suicide rates in young adults were accompanied by  
33  
34 rising suicide rates in other methods at the national and local level.<sup>35 36</sup> Our study also found  
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36 this trend, especially among males. Similarly, other countries experienced decreases in suicide  
37  
38 rates by firearms and increased suicide rates by hanging over time.<sup>37 38</sup> This may due to  
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40 substitution of methods (e.g., hanging) for firearms, especially after 1996 when availability of  
41  
42 firearms dropped in Australia.<sup>39</sup> Suicide rates by firearms in rural areas (with a higher  
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44 availability of firearms) remained higher than suicide rates in urban areas. More evidence,  
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46 including the interaction between socio-economic changes and suicide methods, still needs to  
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48 be assessed, especially for recent years.  
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55 Only a small percentage of both the population and suicide cases were for those aged 75 and  
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57 over, thus many LGAs had no suicides, or a higher suicide rate among older adults, especially  
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3 in rural and remote areas. Areas with a higher risk of suicide also often have lower socio-  
4 economic status, along with higher proportion of Indigenous population.<sup>14</sup> Our previous study  
5 indicated that Mornington Shire in QLD and Bathurst-Melville in north of NT showed a much  
6 higher suicide risk, proportion of Indigenous population and lower socio-economic status than  
7 the national average, and both were indicated as high risk clusters using spatial cluster  
8 analysis (1999-2003).<sup>14</sup> Suicide by hanging has also increased in Indigenous communities,  
9 similar to other areas and population groups.<sup>38</sup>

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19 Misclassification of suicide as the cause of death may also influence results. For example,  
20 Williams et al[REF No.] reported that suicide rates in Queensland from the Queensland  
21 Suicide Register (QSR) were higher than those based on Australian Bureau of Statistics  
22 (ABS) data, with the disparity attributable to information management and definition of  
23 suicidal behaviours.<sup>47</sup> Thus the QLD suicide rate using ABS data was lower than using QSR  
24 database, especially after 2000. However, the ABS had a higher standard for evaluating the  
25 causes of deaths, e.g., complete documents from hospital or police, which confirmed the  
26 accuracy of information of current suicide database.<sup>48</sup> To ensure the consistency of the suicide  
27 data across different states the present study was restricted to ABS suicide data.

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Recommendations on future research and public interventions can be proposed based on the results of this study. Firstly, more details (e.g., health and financial status, alcohol and drugs use, and family conflicts history) of suicide victims need to be acquired to help public health policy makers and health workers to design and implement suicide control and prevention strategies targeting particular population groups (e.g., male young adults) and areas (e.g., Indigenous communities). Suicide by firearms remains a significant method especially in rural and remote areas. Gatekeeper education and training in the rural primary healthcare setting may also be an approach in the identification of local vulnerable populations potentially at risk of suicidal behaviour. Education of primary health workers and the general population

1  
2 important in reducing suicidal behaviours,<sup>51-54</sup> and effectiveness of health education programs  
3  
4 needs to be assessed locally. These activities should be explored at a local level, especially in  
5  
6 high risk areas and population groups, to assess and improve the effectiveness of suicide  
7  
8 prevention programs. Socioeconomic variables (e.g., income and unemployment)<sup>55 56</sup> and  
9  
10 environmental factors (e.g., temperature, rainfall)<sup>57-59</sup> also are associated with suicide. The  
11  
12 association of these factors on suicide by geographic markers should also be addressed by  
13  
14 time series analysis and spatial modelling analysis. This study has explored patterns of suicide  
15  
16 across population groups and by suicide methods over time and space, and have shown  
17  
18 important differences by high risk population groups, local areas and specific suicide  
19  
20 methods. Suicide is a complex issue, and cross-sectorial and multi-disciplinary approaches  
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22 need to also incorporate this geographic variability in key socio-demographic and behavioural  
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24 antecedents.  
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### 33 **Contributorship statement**

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36 Xin Qi designed the study, implemented all statistical analyses and drafted the manuscript.  
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38 Shilu Tong conceptualised the idea and revised the study protocol, especially the research  
39  
40 design and data analysis. Wenbiao Hu provided advice on statistical analyses and  
41  
42 interpretation of the results. Andrew Page helped interpreting the results and drafting the  
43  
44 manuscript.  
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### 48 **Competing interests**

49  
50  
51 We declare that we have no competing interests.  
52  
53

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4  
5 was supported by a NHMRC Research Fellowship (#553043).  
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### 8 **Data sharing**

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10 No additional data available  
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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005)

Population group	Age group 15 to 34			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
<b>By sex</b>															
Male	15,059	28.29	2.23 (2.19, 2.27)	12,672	25.61	2.02 (1.98, 2.06)	5,986	22.35	1.77 (1.72, 1.81)	2,091	30.98	2.45 (2.34, 2.56)	35,942	20.32	1.61 (1.58, 1.63)
Female	3,242	6.12	0.48 (0.47, 0.50)	3,556	7.14	0.56 (0.55, 0.58)	1,818	6.48	0.51 (0.49, 0.54)	682	6.14	0.49 (0.45, 0.52)	9,351	5.17	0.41 (0.40, 0.42)
<b>By region</b>															
Capital cities	11,267	16.28	1.29 (1.26, 1.31)	9,736	15.68	1.24 (1.21, 1.27)	4,568	14.21	1.12 (1.09, 1.16)	1,674	15.45	1.22 (1.16, 1.28)	27,332	12.32	0.97 (0.96, 0.99)
Regional centres	3,423	17.57	1.39 (1.34, 1.44)	3,269	17.72	1.40 (1.35, 1.45)	1,550	13.65	1.03 (1.03, 1.14)	584	15.96	1.26 (1.16, 1.37)	8869	12.86	1.02 (1.00, 1.04)
Rural & remote areas	3,611	20.58	1.63 (1.57, 1.68)	3,223	17.23	1.36 (1.31, 1.41)	1,686	14.88	1.18 (1.12, 1.23)	515	15.37	1.21 (1.11, 1.32)	9092	13.55	1.07 (1.05, 1.09)
<b>By methods</b>															
Firearms & other explosives	2,795	2.63	0.21 (0.20, 0.22)	2,285	2.30	0.18 (0.18, 0.19)	1,674	3.05	0.24 (0.23, 0.25)	556	3.11	0.25 (0.23, 0.27)	7,348	2.07	0.16 (0.16, 0.17)
Gases & vapours	3,457	3.25	0.26 (0.25, 0.27)	4,104	4.13	0.33 (0.32, 0.34)	1,277	2.33	0.18 (0.17, 0.20)	375	2.10	0.17 (0.15, 0.18)	9,214	2.60	0.20 (0.20, 0.21)
Hanging	7,366	6.93	0.55 (0.54, 0.56)	4,927	4.96	0.39 (0.38, 0.41)	2,301	4.20	0.33 (0.32, 0.35)	901	5.05	0.40 (0.37, 0.43)	15,620	4.40	0.35 (0.34, 0.35)
Solid or liquid substances	2,166	2.04	0.16 (0.16, 0.17)	2,863	2.88	0.23 (0.22, 0.24)	1,333	2.43	0.19 (0.18, 0.20)	434	2.43	0.19 (0.18, 0.21)	6,807	1.92	0.15 (0.15, 0.15)
Other	2,517	1.26	0.19 (0.18, 0.20)	2,049	2.06	0.16 (0.16, 0.17)	1,219	2.22	0.18 (0.17, 0.19)	507	2.84	0.23 (0.21, 0.25)	6,294	1.78	0.14 (0.14, 0.14)
<b>By region and by sex</b>															
Male															
Capital cities	9,072	26.66	2.08 (2.03, 2.13)	7,439	24.59	1.92 (1.87, 1.97)	3,358	21.86	1.71 (1.65, 1.77)	1,179	30.02	2.35 (2.22, 2.49)	21,107	19.63	1.53 (1.51, 1.56)
Regional centres	2,868	29.90	2.33 (2.25, 2.42)	2,593	28.60	2.23 (2.15, 2.32)	1,213	22.21	1.74 (1.64, 1.84)	468	32.80	2.57 (2.35, 2.81)	7,173	21.39	1.67 (1.63, 1.71)
Rural/remote areas	3,119	32.46	2.72 (2.62, 2.82)	2,640	25.99	2.16 (2.08, 2.24)	1,415	23.73	1.94 (1.84, 2.04)	444	31.82	2.60 (2.37, 2.85)	7,662	21.39	1.77 (1.73, 1.82)
Female															
Capital cities	2,195	6.40	0.50 (0.48, 0.52)	2,297	7.39	0.58 (0.55, 0.60)	1,210	7.33	0.57 (0.54, 0.61)	495	7.26	0.57 (0.52, 0.62)	6,225	5.58	0.44 (0.42, 0.45)
Regional centres	555	5.75	0.45 (0.42, 0.49)	676	7.37	0.58 (0.53, 0.62)	337	5.83	0.46 (0.41, 0.51)	116	5.27	0.41 (0.34, 0.50)	1,696	4.91	0.38 (0.37, 0.40)
Rural/remote areas	492	5.43	0.43 (0.39, 0.47)	583	6.12	0.51 (0.47, 0.55)	271	4.71	0.39 (0.34, 0.43)	71	3.41	0.28 (0.22, 0.35)	1,430	4.13	0.34 (0.33, 0.36)
<b>By methods and by region</b>															
Capital cities															
Firearms & other explosives	1,148	1.66	0.13 (0.12, 0.14)	913	1.47	0.12 (0.11, 0.12)	626	1.95	0.15 (0.14, 0.17)	211	1.95	0.16 (0.14, 0.18)	2,908	1.31	0.10 (0.10, 0.11)
Gases & vapours	2,299	3.32	0.26 (0.25, 0.27)	2,420	3.90	0.31 (0.30, 0.32)	732	2.28	0.18 (0.17, 0.19)	222	2.05	0.16 (0.14, 0.19)	5,674	2.56	0.20 (0.20, 0.21)
Hanging	4,339	6.27	0.50 (0.48, 0.51)	3,017	4.86	0.38 (0.37, 0.40)	1,470	4.57	0.36 (0.34, 0.38)	591	5.45	0.43 (0.40, 0.47)	9,478	4.27	0.30 (0.30, 0.31)
Solid or liquid substances	1,547	2.24	0.18 (0.17, 0.19)	1,864	3.00	0.24 (0.23, 0.25)	901	2.80	0.22 (0.21, 0.24)	284	2.62	0.21 (0.19, 0.23)	4,600	2.07	0.16 (0.16, 0.17)
Other	1,934	2.79	0.22 (0.21, 0.23)	1,522	2.45	0.19 (0.18, 0.20)	839	2.61	0.21 (0.19, 0.22)	366	3.38	0.27 (0.24, 0.30)	4,672	2.11	0.17 (0.16, 0.17)
Regional centres															
Firearms & other explosives	603	3.09	0.25 (0.23, 0.27)	495	2.68	0.21 (0.20, 0.23)	368	3.24	0.26 (0.23, 0.28)	131	3.58	0.28 (0.24, 0.33)	1,606	2.33	0.19 (0.18, 0.19)
Gases & vapours	631	3.24	0.26 (0.24, 0.28)	861	4.67	0.37 (0.35, 0.40)	275	2.42	0.19 (0.17, 0.22)	91	2.49	0.20 (0.16, 0.24)	1,858	2.70	0.21 (0.20, 0.22)
Hanging	1,502	7.71	0.61 (0.58, 0.64)	1,026	5.56	0.44 (0.41, 0.47)	456	4.02	0.32 (0.29, 0.35)	187	5.11	0.40 (0.35, 0.46)	3,200	4.65	0.37 (0.36, 0.38)
Solid or liquid substances	344	1.77	0.14 (0.13, 0.16)	570	3.09	0.25 (0.23, 0.27)	258	2.27	0.18 (0.16, 0.20)	92	2.51	0.20 (0.16, 0.24)	1,268	1.84	0.15 (0.14, 0.15)
Other	343	1.76	0.14 (0.13, 0.16)	317	1.72	0.14 (0.12, 0.15)	193	1.70	0.14 (0.12, 0.16)	83	2.27	0.18 (0.15, 0.22)	937	1.36	0.11 (0.10, 0.12)

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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005, continued)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
<b>Rural/remote areas</b>															
Firearms & other explosives	1,044	5.95	0.47 (0.44, 0.50)	877	4.69	0.37 (0.35, 0.40)	680	6.00	0.48 (0.44, 0.51)	214	6.39	0.51 (0.44, 0.52)	2,834	4.22	0.33 (0.32, 0.35)
Gases & vapours	527	3.00	0.24 (0.22, 0.26)	823	4.40	0.35 (0.33, 0.37)	270	2.38	0.19 (0.17, 0.21)	62	1.85	0.15 (0.11, 0.19)	1,682	2.51	0.20 (0.19, 0.21)
Hanging	1,525	8.69	0.69 (0.65, 0.72)	884	4.73	0.37 (0.35, 0.40)	375	3.31	0.26 (0.24, 0.29)	123	3.67	0.29 (0.24, 0.35)	2,942	4.38	0.35 (0.33, 0.36)
Solid or liquid substances	275	1.57	0.12 (0.11, 0.14)	429	2.29	0.18 (0.17, 0.20)	174	1.54	0.12 (0.11, 0.14)	58	1.73	0.14 (0.11, 0.18)	939	1.40	0.11 (0.10, 0.12)
Other	240	1.37	0.11 (0.10, 0.12)	210	1.12	0.09 (0.08, 0.10)	187	1.65	0.13 (0.11, 0.15)	58	1.73	0.14 (0.11, 0.18)	695	1.04	0.08 (0.08, 0.09)
<b>By methods and by sex</b>															
<b>Male</b>															
Firearms & other explosives	2,555	4.80	0.38 (0.37, 0.40)	2,123	4.29	0.34 (0.33, 0.36)	1,605	5.99	0.48 (0.45, 0.50)	551	8.16	0.65 (0.60, 0.70)	6,869	3.88	0.31 (0.30, 0.32)
Gases & vapours	2,961	5.56	0.44 (0.42, 0.46)	3,428	6.93	0.55 (0.53, 0.57)	1,091	4.07	0.32 (0.30, 0.34)	324	4.80	0.38 (0.34, 0.43)	7,805	4.41	0.35 (0.34, 0.36)
Hanging	6,267	11.77	0.93 (0.91, 0.96)	4,115	8.32	0.66 (0.64, 0.68)	1,821	6.80	0.54 (0.51, 0.56)	670	9.93	0.79 (0.73, 0.85)	12,963	7.33	0.58 (0.57, 0.59)
Solid or liquid substances	1,301	2.44	0.19 (0.18, 0.20)	1,573	3.18	0.25 (0.24, 0.27)	671	2.51	0.20 (0.18, 0.21)	198	2.93	0.23 (0.20, 0.27)	3,746	2.12	0.17 (0.16, 0.17)
Other	1,975	3.72	0.29 (0.28, 0.31)	1,433	2.89	0.23 (0.22, 0.24)	798	2.98	0.24 (0.22, 0.25)	348	5.16	0.41 (0.37, 0.46)	4,559	2.58	0.20 (0.20, 0.21)
<b>Female</b>															
Firearms & other explosives	240	0.45	0.04 (0.03, 0.04)	162	0.33	0.03 (0.02, 0.03)	69	0.25	0.02 (0.02, 0.03)	5	0.05	0.00 (0.00, 0.01)	479	0.26	0.02 (0.02, 0.02)
Gases & vapours	496	0.94	0.07 (0.07, 0.08)	676	1.36	0.11 (0.10, 0.12)	186	0.66	0.05 (0.05, 0.06)	51	0.46	0.04 (0.03, 0.05)	1,409	0.78	0.06 (0.06, 0.07)
Hanging	1,099	2.07	0.16 (0.15, 0.17)	812	1.63	0.12 (0.11, 0.13)	480	1.71	0.14 (0.12, 0.15)	231	2.08	0.17 (0.15, 0.19)	2,657	1.47	0.12 (0.11, 0.12)
Solid or liquid substances	865	1.63	0.13 (0.12, 0.14)	1,290	2.59	0.21 (0.19, 0.22)	662	2.36	0.19 (0.17, 0.20)	236	2.13	0.17 (0.15, 0.19)	3,061	1.69	0.13 (0.13, 0.14)
Other	542	1.03	0.08 (0.07, 0.09)	616	1.23	0.10 (0.09, 0.11)	421	1.50	0.12 (0.11, 0.13)	163	1.42	0.12 (0.10, 0.14)	1,745	0.97	0.08 (0.07, 0.08)
<b>Total suicide</b>	<b>18,301</b>	<b>17.23</b>	<b>1.36 (1.34, 1.38)</b>	<b>16,228</b>	<b>16.35</b>	<b>1.29 (1.27, 1.32)</b>	<b>7,804</b>	<b>14.23</b>	<b>1.12 (1.10, 1.15)</b>	<b>2,773</b>	<b>15.54</b>	<b>1.23 (1.18, 1.28)</b>	<b>45,293</b>	<b>12.66</b>	

Note: population size (all and by groups) was based on the mean value of Australian population census (1986, 1991, 1996, 2001, 2006). Reference group: annual average of total suicide in Australia between 1986 and 2005 after adjusting for population changes over years.

Table 2: Suicide rate change over time (population groups and suicide methods)

	RR	95% CI	P-value
All suicide	0.99	0.99, 0.99	<0.001
Male	0.99	0.99, 0.99	<0.001
Female	0.99	0.99, 0.99	<0.001
Age 15-34	0.99	0.99, 1.00	<0.001
Age 35-54	1.00	0.99, 1.00	0.009
Age 55-74	0.97	0.97, 0.98	<0.001
Age 75 & over	0.97	0.97, 0.98	<0.001
Urban areas	0.99	0.99, 0.99	0.001
Regional areas	1.00	0.99, 1.00	0.019
Rural & remote areas	1.00	0.99, 1.00	0.022
Firearm	0.93	0.93, 0.94	<0.001
Hanging	1.04	1.03, 1.04	<0.001
Gas and vapour	0.99	0.98, 0.99	<0.001
Solid or liquid substances	0.97	0.96, 0.97	<0.001
Other methods	0.98	0.98, 0.98	<0.001

RR: Relative Risk. Reference group: suicide in 1986 for each population group.

Table 3: Male suicide rate by firearms change over time (Reference: mean annual male suicide rate in 1986-1990 by each of age groups and types of regions)

Population group	Time period	RR	95% CI	P-value
15-34 yrs	2001-2005	0.22	0.08, 0.36	<0.001
	1996-2000	0.39	0.28, 0.51	<0.001
	1991-1995	0.78	0.69, 0.87	<0.001
35-54 yrs	2001-2005	0.39	0.26, 0.51	<0.001
	1996-2000	0.52	0.40, 0.64	<0.001
	1991-1995	0.83	0.72, 0.94	0.001
55-74 yrs	2001-2005	0.43	0.28, 0.57	<0.001
	1996-2000	0.63	0.49, 0.76	<0.001
	1991-1995	0.88	0.75, 1.01	0.049
75 yrs & over	2001-2005	0.45	0.21, 0.69	<0.001
	1996-2000	0.66	0.43, 0.89	<0.001
	1991-1995	0.83	0.59, 1.06	0.103
Capital cities	2001-2005	0.33	0.21, 0.45	<0.001
	1996-2000	0.46	0.35, 0.57	<0.001
	1991-1995	0.78	0.69, 0.88	<0.001
Regional centres	2001-2005	0.32	0.17, 0.48	<0.001
	1996-2000	0.47	0.33, 0.61	<0.001
	1991-1995	0.78	0.65, 0.90	<0.001
Rural and remote areas	2001-2005	0.41	0.29, 0.53	<0.001
	1996-2000	0.61	0.50, 0.72	<0.001
	1991-1995	0.91	0.81, 1.00	0.048



**FIGURE LEGENDS**

Figure 1: suicide rates over time and sub-groups (per 100,000)

A: Sex and age groups; B: Sex and urban rural differences; C: Sex and methods;

Figure 2: suicide rates over time and methods (per 100,000, annual average)

A: Methods and age groups; B: Methods and urban rural difference

Figure 3: Suicide rates among different groups across Australia (1986-2005)

Figure 4: Suicide rates by self-harm over time and across space in Australia (1986-2005)

Supplemental 1: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 1).

Supplemental 2: Time trend of suicide rates by methods, sexes, age groups and urban/rural areas (part 2).

# Dynamic pattern of suicide in Australia, 1986–2005, a descriptive-analytic study

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## ABSTRACT

**Objective:** This study explores the spatiotemporal variations of suicide across Australia from 1986 to 2005, discusses the reasons for dynamic changes, and considers future suicide research and prevention strategies.

**Design:** Suicide (1986–2005) and population data were obtained from the Australian Bureau of Statistics. A series of analyses were conducted to examine the suicide pattern by sex, method and age group over time and geography.

**Results:** Differences in suicide rates across sex, age groups and suicide methods were found across geographical areas. Male suicides were mainly completed by hanging, firearms, gases and self-poisoning. Female suicides were primarily completed by hanging and self-poisoning.

**Suicide rates were higher** in rural areas than urban areas (capital cities and regional centres). Suicide rates by firearms were higher in rural areas than urban areas, while the pattern for self-poisoning showed the reverse. Suicide rates did not fluctuate substantially for the total population and those aged between 15 and 54, while suicide decreased among 55 years and over during the study period. There was a decrease of suicide by firearms during the study period especially after 1996 when new firearm control law was implemented; while suicide by hanging kept continued to increase. Areas with a high proportion of Indigenous population (e.g., northwest of Queensland and top north of Northern Territory) had showed a substantial increase in suicide incidence after 1995.

**Conclusions:** Suicide rates varied over time and space and across sexes, age groups, suicide methods. This study provides detailed patterns of suicide to inform suicide control and prevention strategies for specific sub-groups and areas of high and increased risk.

**Key words:** suicide, Australia, pattern

## STRENGTHS AND LIMITATIONS OF THE STUDY

This study presents 20-years of Australian national suicide data stratified by population group, method, time and geography, and provides valuable information for examining suicide trends in Australia.

Different levels of spatial scale (Local Government Area (LGA) and Statistical Local Area (SLA)) were combined to display the spatial distribution of suicide patterns; with boundary changes over the period adjusted using advanced GIS methods.

This study examined population-level suicide patterns using aggregated data. Detailed individual information such as marriage, employment, Indigenous status and health status prior to suicide was not available in the current dataset.

The quality of suicide data may vary over time. There is some evidence suggesting that some suicide deaths were misclassified during the latter part of the study period, and that absolute numbers of suicides were underestimated.

The suicide database was acquired a few years ago and may not indicate the trend of suicide after 2005.

## INTRODUCTION

Suicide remains a major public health issue globally, with about 1 million suicide deaths annually.<sup>1</sup> Suicide patterns, including suicide methods, time and geographical variation have been explored in many countries and regions, such as Brazil,<sup>2</sup> China,<sup>3</sup> India,<sup>4</sup> Russia,<sup>5</sup> Taiwan,<sup>6</sup> United Kingdom,<sup>7</sup> and United States.<sup>8</sup> In Australia, suicide rates have fluctuated since suicide registration started in the early of 1920s.<sup>9-11</sup> The trend of annual suicide rates from 1980 was relatively stable (around 9 to 10 per 100,000) except for a peak in 1997 (around 14.6 per 100,000).<sup>9-11</sup> However, there were still approximately 2,000 suicide deaths

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2 annually, mainly in male adults (25-54 years age). Thus, it is vital to understand the variations  
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4 of suicide patterns over time, space, population groups (age, sex and ethnic groups) and the  
5  
6 possible reasons for these variations, in order to design effective suicide control and  
7  
8 prevention programs. Previous reports and studies have explored suicide patterns in Australia  
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10 over time,<sup>9-12</sup> methods<sup>13</sup> and space.<sup>14</sup> From a geographical perspective, the Australian Bureau  
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12 of Statistics (ABS) suicide reports cover a long period (1921 to 2010) presented at state and  
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14 capital city level.<sup>9-11</sup> However, suicide patterns at the smaller area (e.g., Local Government  
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16 Area, or LGA) level, especially in rural and remote areas, were not routinely provided in ABS  
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18 reports. A study by Cheung et al examined the spatial pattern of suicide in Australia after  
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20 2000.<sup>15</sup> However, this study did not examine suicide pattern before 2000 or by suicide  
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22 methods; thus the dynamic spatial pattern of suicide and high risk areas of suicide by  
23  
24 particular method (e.g., firearms) could not be demonstrated. ABS reports indicated that most  
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26 suicide occur in urban areas in Australia, while fewer suicides were recorded in rural and  
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28 remote areas, areas of lower population density. It is therefore important to select suitable  
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30 spatial scales in examining the geographic pattern of suicide in Australia. The studies of  
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32 spatial patterns of suicide in earlier years (e.g. before 1995) used relative large spatial scales  
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34 (e.g., Statistical Division rather than LGA), which may mask the spatial variation of suicide in  
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36 some rural areas (e.g., in Western Australia and Northern Territory) due to their large  
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38 geographic size.<sup>16 17</sup> The spatial patterns of suicide by different population groups and suicide  
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40 methods over the long term covering both earlier years (e.g., before 2000) and more recent  
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42 years (after 2000) using suitable spatial scales (e.g., LGA) have not yet been examined.  
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44 Trends in suicide rates over time are likely to differ across population groups (e.g., young or  
45  
46 older adults) and area (e.g., suicide by firearms in urban or rural areas). Thus, this study  
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48 examined long-term (both dynamic and static), spatiotemporal patterns of Australian national  
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50 suicide, using a range of different combinations of age, time, method, and location from the  
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52 period 1986-2005.  
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## DESIGN

### Data source

Unit record data of suicide deaths between 1986 and 2005 were obtained from the Australian Bureau of Statistics (ABS), including sex, International Classification of Disease (ICD) Code (ICD 9: 950.0-959.9; ICD 10: X60-X84)<sup>18 19</sup> relating to suicide or self-inflicted injury, age, country of birth, date of suicide and Statistical Local Area (SLA) code for place of suicide occurrence. Access to unit record suicide for these variables from the ABS after 2005 was not possible, as the related procedure is under review. As SLA boundaries have changed dramatically over the study period, especially in urban areas, we chose Local Governmental Area (LGA) as the standard geographical unit to explore the spatial pattern of suicide. Choosing LGA as the spatial scale also aims to keep the balance between including sufficient case numbers of suicide in each geographical unit and using too large a geographical unit. Each LGA is composed of one or more SLAs, and LGA boundaries are relatively stable over the study period. The Australian Standard Geographical Classification (ASGC), updated annually, was used to incorporate SLA codes into LGA codes, examine and adjust for SLA/LGA boundary changes over time. CDATA 2001, a product issued by ABS, provided digital boundaries and socio-demographic data of Australia (including 1991, 1996 and 2001 population census data at SLA/LGA levels, based on 2001 Census boundary) and was applied in MapInfo 10.5 software package for map display.<sup>20</sup> Population data (SLA/LGA levels) in 1986 and 2006 Censuses from ABS were merged with 2001 Census data after adjustment for boundary changes using ASGC references. The suicide rates in different groups over time and across LGAs were then calculated. In this study, we categorized LGAs as: metropolitan areas of capital cities, regional centres (other LGA named as “city” outside of capital cities, e.g., City of Townville), or rural and remote areas (remaining LGAs).

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2  
3 Most areas in South Australia (SA) and Northern Territory (NT) have a very low population  
4 density and were defined as unincorporated areas by ABS at the LGA level. However, these  
5 areas were also composed of 27 SLAs according to the 2001 Census data. Thus we applied  
6 SLA data in unincorporated areas in SA and NT to provide more detailed geographic  
7 information. In the 2001 Census, Australia was divided into 628 LGAs, plus 27 SLAs in the  
8 unincorporated areas of SA and NT. Ethical approval was granted by the Human Research  
9 Ethics Committee, Queensland University of Technology.  
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### 19 **Statistical analyses**

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22 Descriptive and mapping approaches were applied to explore the age, sex, method, time and  
23 regional-specific patterns of suicide cases and rates. Firstly, we explored the basic pattern of  
24 suicide among different groups by calculating suicide rates, Rate Ratios and **95% Confidence**  
25 **Interval** (CI) to the annual mean national suicide rate over the study period using the annual  
26 average suicide number **in the whole Australian population** (1986-2005) as reference group.  
27  
28 Temporal trends of suicide rates in population groups were then examined, using yearly data  
29 and Poisson regression, offset by the natural logarithm of the population size and adjusting for  
30 year as a covariate. All the statistical analyses were implemented by SPSS 21.0.<sup>21</sup> Finally  
31 suicide rates at the LGA level were applied to display suicide rates by sex, age group and  
32 method using mapping approaches by MapInfo 10.5.<sup>20</sup> We used the annual average sex-  
33 specific rates for the whole of Australia over the entire study period as the reference to  
34 calculate age-adjusted standardised mortality ratios (SMRs) for both sexes.  
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### 49 **RESULTS**

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52 This study included 45,293 suicide deaths for the 20 year period. Table 1 indicates that most  
53 suicides occurred in those aged between 15 and 54 and occurred in capital cities and regional  
54 centres, as the majority of Australian population live in urban areas. However, suicide rates in  
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2 rural and remote areas were higher than in urban areas. Approximately 80% of suicides were  
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4 males, with the majority of suicides occurring in those aged between 15 and 54 years,  
5  
6 although older males (75-year and over) had higher suicide rates than males in other age  
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8 groups. Four methods accounted for the majority of suicides: (1) firearms, air guns and other  
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10 explosives (simplified as firearms, 16% of total suicides); (2) hanging (35% of total); (3)  
11  
12 gases and vapours (20% of total); (4) solid or liquid substances (15% of total). The Rate Ratio  
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14 and 95% Confident Interval (CI) of suicide in each population group and by different methods  
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16 were calculated, using annual average suicide incidence in the study period in Australia as a  
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18 reference (Table 1). We also applied Chi square test to assess the distribution of suicide cases  
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20 by population groups and method (all differences were statistically significant).  
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26 Table 1 about here  
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29 Figure 1 shows time-series trends by different groups. There was a peak in the suicide rate  
30  
31 among the total population during the period 1996 to 1998, particularly in males aged from 15  
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33 to 34 years (A), males in rural and remote areas (B) and suicide completed by hanging (C). In  
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35 the early years of the study period, suicide incidence among 55 years and over was higher  
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37 than those below 55 years, however, rates decreased over time and were lower than those of  
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39 young and middle aged adults after 2000, particular in males (A). Suicide rates among 15 to  
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41 34 years had peaks in 1997 and 1998 (especially for males peaking at approximately 34 per  
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43 100,000 and at approximately 21 per 100,000 for total suicide rates) and kept relatively steady  
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45 in other years (25 to 28 per 100,000 for males and 14 to 17 per 100,000 for the total  
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47 population) (A). In 1986, firearms and other explosives were the most common methods of  
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49 suicide in Australia (over 6 per 100,000 among males). However, the rate dropped to around 2  
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51 per 100,000 in 2005. By contrast, male suicide rates by hanging rose from 3.8 per 100,000 in  
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53 1986 to 9.4 per 100,000 in 2005, after experiencing a peak of 10.6 per 100,000 in 1998 (C).  
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55 Suicide rates by hanging in males dropped after 1997 but were still higher than the early years  
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3 of the study period. Figure 2 used 5-year periods to explore method-specific suicide by age  
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5 groups and urban rural differences. Suicide rates by firearms decreased over the study period,  
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7 especially among those aged 15 to 54 years and in rural and remote areas (Figure 2A and 2B);  
8  
9 while suicide by hanging increased dramatically and reached a peak during 1996 to 2000,  
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11 especially among aged 15-54 years (Figure 2A). For those aged 55 and older, suicide rates by  
12  
13 hanging and firearms remained more stable than for those aged 54 and younger over the study  
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15 period. Suicide rates by gases and vapours, solid and liquid substances fluctuated over the  
16  
17 study period among all population groups (Figure 2A and 2B). Further detailed stratification  
18  
19 of suicide incidence trends over time in each population group and suicide methods are  
20  
21 presented in Supplemental 1 and 2. Poisson regression was implemented to examine the time  
22  
23 series trend of suicide rates across population groups and by methods (Table 2). Suicide rates  
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25 by sex, 55 years and over, urban residence, and suicide by firearms, solid and liquid  
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27 substances decreased over time. However, suicide rates by hanging significantly increased.  
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29 **Table 3 indicated that male suicide rates by firearms kept decreasing across the whole study**  
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31 **period, especially from period 1991-1995 to period 1996-2000.**  
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37 Figure 1 about here

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45 Table 3 about here  
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49 Figure 3 shows that among 15 to 34 years, the north and central south areas of the Northern  
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51 Territory (NT), the northeast and some southern parts of Western Australia (WA), the  
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53 northwest and central inland areas of Queensland (QLD) and some inland areas of New South  
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55 Wales (NSW) had higher suicide (2A). The patterns were also similar for males (NT, QLD  
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57 and WA in B1). Those aged between 35 and 74 had fewer high-risk areas than those aged 15  
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3 to 34 (A2 and A3). For those aged 75 and over, suicide in northern and inland QLD and a  
4  
5 small number of LGAs in NSW and WA were higher than other areas. Around 40% of total  
6  
7 LGAs and unincorporated SLAs in NT and SA had no suicide data. Compared with males, a  
8  
9 greater number of areas had no female suicide data (2B). Rural and remote areas had lower  
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11 rates by self-poisoning than urban areas, except for some LGAs in inland QLD, east SA and  
12  
13 south WA (2C).  
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17 Figure 3 about here  
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20 As suicide rates by firearms and by hanging had more significant changes over time than  
21  
22 other methods and by population groups, we also explored whether this trend existed in  
23  
24 spatial scales over time by stratifying the whole study period into four 5-year periods (Figure  
25  
26 4). Figure 4A shows that suicide rates by hanging was low in the early years of study period  
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28 (A1), and very few suicides occurred in rural and remote areas in WA, NT, QLD and NSW.  
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30 However, the suicide rate by hanging increased in most areas of Australia since 1986. North  
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32 of WA, NT and SA, north of QLD and even urban LGAs had much higher suicide rates  
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34 between 1996 and 2005 compared with rates in earlier years. Some areas (e.g., Mornington  
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36 Shire (MTS) of northwest QLD, Bathurst-Melville (BM) of NT) had dramatic increases in  
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38 suicide by hanging. Both of these areas experienced an increase in the number of suicide  
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40 cases (especially for suicide by hanging) between 1996 and 2005 (27 in MTS, 23 males and  
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42 26 by hanging; 23 in BM, 22 males and 20 by hanging), compared to the period between 1986  
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44 and 1995 (4 in MTS, male and 3 by hanging; 3 in BM, male and by hanging). Suicide rates by  
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46 hanging in MTS increased from 28.79 (1986-1995, annual average) to 236.32 per 100,000  
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48 (1996-2005, annual average); and in BM increased from 14.10 (1986-1995, annual average)  
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50 to 86.39 per 100,000 (1996-2005, annual average). However, the trend of suicide by firearms  
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52 was opposite to that of suicide by hanging (Figure 4B), especially in SA and NT, north and  
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54 inland areas in NSW and QLD, and middle of WA (B1 and B2). In general, unincorporated  
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3 NT and SA had a greater number of suicide cases after 1996 (123 from 1996 to 2005)  
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5 compared with the period before 1996 (22 from 1986-1995).  
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8 Figure 4 about here  
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## 10 **DISCUSSION**

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14 This study explored suicide patterns for a range of different combinations of age, time,  
15 method, and location in Australia, using both dynamic (trends over time) and static (averages  
16 over the entire study period) approaches. Males accounted for most suicides, and the suicide  
17 rate was higher among young and middle-aged adults, in rural and remote areas, more  
18 commonly by hanging and by firearms. Suicide rate among those aged 55 years and over  
19 declined substantially over the study period, especially for males. Suicide by firearms  
20 decreased during the study period, while suicide by hanging kept increasing, especially in  
21 males and rural and remote areas. The spatial and spatiotemporal patterns of suicide were  
22 consistent with yearly mean and temporal trends of suicide among different groups.  
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35 Elderly and upper middle-aged adults (55-years and over) usually have more loneliness and  
36 other health issues (e.g., chronic diseases) compared with the younger age population, which  
37 may lead to psychiatric symptoms, e.g., anxiety, sense of hopelessness and despair.<sup>22 23</sup> And  
38 older adults may be less likely to seek psychiatric support when they have relevant symptoms,  
39 especially in earlier years (e.g., before the middle of 1990s).<sup>24</sup> However, suicide rates among  
40 this age group gradually decreased in the study period, especially after 2000, occurring  
41 contemporaneously with an increased use of antidepressants among older adults.<sup>25</sup>  
42 Antidepressants can reduce psychological disorders, e.g., depression, and suicidal behaviours  
43 among the elderly, especially when combined with other interventions (e.g., counselling and  
44 family support).<sup>26</sup> Selective serotonin reuptake inhibitors have less side effects (e.g.,  
45 **cardiovascular impairment** and drug interactions) than other drugs, and have been widely  
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2 recommended to older adults from clinics.<sup>27 28</sup> Studies in other countries have also provided  
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4 evidence about the protective effect of antidepressants on severe depression and suicidal  
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6 behaviour, although treatment of other levels of depression are still not clear.<sup>29 30</sup>  
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10 Suicide rates by firearms decreased over the study period while suicide by hanging increased,  
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12 especially among 54 years and younger. A study in Victoria indicated that a decreased  
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14 registration of firearms and lower suicide rates were significantly correlated from 1997 to  
15  
16 2000.<sup>31</sup> Before 1996, the importation of firearms was controlled by the Commonwealth; and  
17  
18 the sales and possession of firearms were regulated by states and territories in Australia.<sup>32</sup>  
19  
20 Some states had lag in progressing firearm control.<sup>33</sup> The Port Arthur Massacre in Tasmania  
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22 led to the enactment of The National Firearms Agreement in 1996, regulating firearm sales,  
23  
24 registration, storage and bans on specific types of firearms nationally.<sup>34</sup> Our study found a  
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26 sharper decline in male suicide rates by firearms from the period 1991-1995 to the period  
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28 1996-2000 than for earlier periods (e.g., period 1991-1995 compared with period 1986-1990),  
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30 suggestive of a sustained impact of the firearm law enforcement after 1996.<sup>31</sup> Other studies  
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32 have suggested that decreased firearm suicide rates in young adults were accompanied by  
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34 rising suicide rates in other methods at the national and local level.<sup>35 36</sup> Our study also found  
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36 this trend, especially among males. Similarly, other countries experienced decreases in suicide  
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38 rates by firearms and increased suicide rates by hanging over time.<sup>37 38</sup> This may due to  
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40 substitution of methods (e.g., hanging) for firearms, especially after 1996 when availability of  
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42 firearms dropped in Australia.<sup>39</sup> Suicide rates by firearms in rural areas (with a higher  
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44 availability of firearms) remained higher than suicide rates in urban areas. More evidence,  
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46 including the interaction between socio-economic changes and suicide methods, still needs to  
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48 be assessed, especially for recent years.  
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55 Only a small percentage of both the population and suicide cases were for those aged 75 and  
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57 over, thus many LGAs had no suicides, or a higher suicide rate among older adults, especially  
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3 in rural and remote areas. Areas with a higher risk of suicide also often have lower socio-  
4 economic status, along with higher proportion of Indigenous population.<sup>14</sup> Our previous study  
5 indicated that Mornington Shire in QLD and Bathurst-Melville in north of NT showed a much  
6 higher suicide risk, proportion of Indigenous population and lower socio-economic status than  
7 the national average, and both were indicated as high risk clusters using spatial cluster  
8 analysis (1999-2003).<sup>14</sup> Suicide by hanging has also increased in Indigenous communities,  
9 similar to other areas and population groups.<sup>38</sup>

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19 Misclassification of suicide as the cause of death may also influence results. For example,  
20 Williams et al[REF No.] reported that suicide rates in Queensland from the Queensland  
21 Suicide Register (QSR) were higher than those based on Australian Bureau of Statistics  
22 (ABS) data, with the disparity attributable to information management and definition of  
23 suicidal behaviours.<sup>47</sup> Thus the QLD suicide rate using ABS data was lower than using QSR  
24 database, especially after 2000. However, the ABS had a higher standard for evaluating the  
25 causes of deaths, e.g., complete documents from hospital or police, which confirmed the  
26 accuracy of information of current suicide database.<sup>48</sup> To ensure the consistency of the suicide  
27 data across different states the present study was restricted to ABS suicide data.

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Recommendations on future research and public interventions can be proposed based on the  
results of this study. Firstly, more details (e.g., health and financial status, alcohol and drugs  
use, and family conflicts history) of suicide victims need to be acquired to help public health  
policy makers and health workers to design and implement suicide control and prevention  
strategies targeting particular population groups (e.g., male young adults) and areas (e.g.,  
Indigenous communities). Suicide by firearms remains a significant method especially in rural  
and remote areas.. Gatekeeper education and training in the rural primary healthcare setting  
may also be an approach in the identification of local vulnerable populations potentially at  
risk of suicidal behaviour. Education of primary health workers and the general population

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2 important in reducing suicidal behaviours,<sup>51-54</sup> and effectiveness of health education programs  
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4 needs to be assessed locally. These activities should be explored at a local level, especially in  
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6 high risk areas and population groups, to assess and improve the effectiveness of suicide  
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8 prevention programs. Socioeconomic variables (e.g., income and unemployment)<sup>55 56</sup> and  
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10 environmental factors (e.g., temperature, rainfall)<sup>57-59</sup> also are associated with suicide. The  
11  
12 association of these factors on suicide by geographic markers should also be addressed by  
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14 time series analysis and spatial modelling analysis. This study has explored patterns of  
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16 suicide across population groups and by suicide methods over time and space, and have  
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18 shown important differences by high risk population groups, local areas and specific suicide  
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20 methods. Suicide is a complex issue, and cross-sectoral and multi-disciplinary approaches  
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22 need to also incorporate this geographic variability in key socio-demographic and behavioural  
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24 antecedents.  
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### 30 **Contributorship statement**

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32  
33 Xin Qi designed the study, implemented all statistical analyses and drafted the manuscript.  
34  
35 Shilu Tong conceptualised the idea and revised the study protocol, especially the research  
36  
37 design and data analysis. Wenbiao Hu provided advice on statistical analyses and  
38  
39 interpretation of the results. Andrew Page helped interpreting the results and drafting the  
40  
41 manuscript. All the authors contributed to the preparation of the final manuscript and  
42  
43 approved the submission. We also thank Dr. Lyle Turner from Monash University for his  
44  
45 comments on the manuscript.  
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### 49 **Competing interests**

50  
51  
52 We declare that we have no competing interests.  
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### 55 **Funding**

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### **Data sharing**

No additional data available

Figure 1: suicide rates over time and sub-groups (per 100,000)

A: Sex and age groups; B: Sex and urban rural differences; C: Sex and methods;

Figure 2: suicide rates over time and methods (per 100,000, annual average)

A: Methods and age groups; B: Methods and urban rural difference

Figure 3: Suicide rates among different groups across Australia (1986-2005)

Figure 4: Suicide rates by self-harm over time and across space in Australia (1986-2005)

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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005)

Population group	Age group 15 to 34			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
<b>By sex</b>															
Male	15,059	28.29	2.23 (2.19, 2.27)	12,672	25.61	2.02 (1.98, 2.06)	5,986	22.35	1.77 (1.72, 1.81)	2,091	30.98	2.45 (2.34, 2.56)	35,942	20.32	1.61 (1.58, 1.63)
Female	3,242	6.12	0.48 (0.47, 0.50)	3,556	7.14	0.56 (0.55, 0.58)	1,818	6.48	0.51 (0.49, 0.54)	682	6.14	0.49 (0.45, 0.52)	9,351	5.17	0.41 (0.40, 0.42)
<b>By region</b>															
Capital cities	11,267	16.28	1.29 (1.26, 1.31)	9,736	15.68	1.24 (1.21, 1.27)	4,568	14.21	1.12 (1.09, 1.16)	1,674	15.45	1.22 (1.16, 1.28)	27,332	12.32	0.97 (0.96, 0.99)
Regional centres	3,423	17.57	1.39 (1.34, 1.44)	3,269	17.72	1.40 (1.35, 1.45)	1,550	13.65	1.03 (1.03, 1.14)	584	15.96	1.26 (1.16, 1.37)	8,869	12.86	1.02 (1.00, 1.04)
Rural & remote areas	3,611	20.58	1.63 (1.57, 1.68)	3,223	17.23	1.36 (1.31, 1.41)	1,686	14.88	1.18 (1.12, 1.23)	515	15.37	1.21 (1.11, 1.32)	9,092	13.55	1.07 (1.05, 1.09)
<b>By methods</b>															
Firearms & other explosives	2,795	2.63	0.21 (0.20, 0.22)	2,285	2.30	0.18 (0.18, 0.19)	1,674	3.05	0.24 (0.23, 0.25)	556	3.11	0.25 (0.23, 0.27)	7,348	2.07	0.16 (0.16, 0.17)
Gases & vapours	3,457	3.25	0.26 (0.25, 0.27)	4,104	4.13	0.33 (0.32, 0.34)	1,277	2.33	0.18 (0.17, 0.20)	375	2.10	0.17 (0.15, 0.18)	9,214	2.60	0.20 (0.20, 0.21)
Hanging	7,366	6.93	0.55 (0.54, 0.56)	4,927	4.96	0.39 (0.38, 0.41)	2,301	4.20	0.33 (0.32, 0.35)	901	5.05	0.40 (0.37, 0.43)	15,620	4.40	0.35 (0.34, 0.35)
Solid or liquid substances	2,166	2.04	0.16 (0.16, 0.17)	2,863	2.88	0.23 (0.22, 0.24)	1,333	2.43	0.19 (0.18, 0.20)	434	2.43	0.19 (0.18, 0.21)	6,807	1.92	0.15 (0.15, 0.15)
Other	2,517	1.26	0.19 (0.18, 0.20)	2,049	2.06	0.16 (0.16, 0.17)	1,219	2.22	0.18 (0.17, 0.19)	507	2.84	0.23 (0.21, 0.25)	6,294	1.78	0.14 (0.14, 0.14)
<b>By region and by sex</b>															
<b>Male</b>															
Capital cities	9,072	26.66	2.08 (2.03, 2.13)	7,439	24.59	1.92 (1.87, 1.97)	3,358	21.86	1.71 (1.65, 1.77)	1,179	30.02	2.35 (2.22, 2.49)	21,107	19.63	1.53 (1.51, 1.56)
Regional centres	2,868	29.90	2.33 (2.25, 2.42)	2,593	28.60	2.23 (2.15, 2.32)	1,213	22.21	1.74 (1.64, 1.84)	468	32.80	2.57 (2.35, 2.81)	7,173	21.39	1.67 (1.63, 1.71)
Rural/remote areas	3,119	32.46	2.72 (2.62, 2.82)	2,640	25.99	2.16 (2.08, 2.24)	1,415	23.73	1.94 (1.84, 2.04)	444	31.82	2.60 (2.37, 2.85)	7,662	21.39	1.77 (1.73, 1.82)
<b>Female</b>															
Capital cities	2,195	6.40	0.50 (0.48, 0.52)	2,297	7.39	0.58 (0.55, 0.60)	1,210	7.33	0.57 (0.54, 0.61)	495	7.26	0.57 (0.52, 0.62)	6,225	5.58	0.44 (0.42, 0.45)
Regional centres	555	5.75	0.45 (0.42, 0.49)	676	7.37	0.58 (0.53, 0.62)	337	5.83	0.46 (0.41, 0.51)	116	5.27	0.41 (0.34, 0.50)	1,696	4.91	0.38 (0.37, 0.40)
Rural/remote areas	492	5.43	0.43 (0.39, 0.47)	583	6.12	0.51 (0.47, 0.55)	271	4.71	0.39 (0.34, 0.43)	71	3.41	0.28 (0.22, 0.35)	1,430	4.13	0.34 (0.33, 0.36)
<b>By methods and by region</b>															
<b>Capital cities</b>															
Firearms & other explosives	1,148	1.66	0.13 (0.12, 0.14)	913	1.47	0.12 (0.11, 0.12)	626	1.95	0.15 (0.14, 0.17)	211	1.95	0.16 (0.14, 0.18)	2,908	1.31	0.10 (0.10, 0.11)
Gases & vapours	2,299	3.32	0.26 (0.25, 0.27)	2,420	3.90	0.31 (0.30, 0.32)	732	2.28	0.18 (0.17, 0.19)	222	2.05	0.16 (0.14, 0.19)	5,674	2.56	0.20 (0.20, 0.21)
Hanging	4,339	6.27	0.50 (0.48, 0.51)	3,017	4.86	0.38 (0.37, 0.40)	1,470	4.57	0.36 (0.34, 0.38)	591	5.45	0.43 (0.40, 0.47)	9,478	4.27	0.30 (0.30, 0.31)
Solid or liquid substances	1,547	2.24	0.18 (0.17, 0.19)	1,864	3.00	0.24 (0.23, 0.25)	901	2.80	0.22 (0.21, 0.24)	284	2.62	0.21 (0.19, 0.23)	4,600	2.07	0.16 (0.16, 0.17)
Other	1,934	2.79	0.22 (0.21, 0.23)	1,522	2.45	0.19 (0.18, 0.20)	839	2.61	0.21 (0.19, 0.22)	366	3.38	0.27 (0.24, 0.30)	4,672	2.11	0.17 (0.16, 0.17)
<b>Regional centres</b>															
Firearms & other explosives	603	3.09	0.25 (0.23, 0.27)	495	2.68	0.21 (0.20, 0.23)	368	3.24	0.26 (0.23, 0.28)	131	3.58	0.28 (0.24, 0.33)	1,606	2.33	0.19 (0.18, 0.19)
Gases & vapours	631	3.24	0.26 (0.24, 0.28)	861	4.67	0.37 (0.35, 0.40)	275	2.42	0.19 (0.17, 0.22)	91	2.49	0.20 (0.16, 0.24)	1,858	2.70	0.21 (0.20, 0.22)
Hanging	1,502	7.71	0.61 (0.58, 0.64)	1,026	5.56	0.44 (0.41, 0.47)	456	4.02	0.32 (0.29, 0.35)	187	5.11	0.40 (0.35, 0.46)	3,200	4.65	0.37 (0.36, 0.38)
Solid or liquid substances	344	1.77	0.14 (0.13, 0.16)	570	3.09	0.25 (0.23, 0.27)	258	2.27	0.18 (0.16, 0.20)	92	2.51	0.20 (0.16, 0.24)	1,268	1.84	0.15 (0.14, 0.15)
Other	343	1.76	0.14 (0.13, 0.16)	317	1.72	0.14 (0.12, 0.15)	193	1.70	0.14 (0.12, 0.16)	83	2.27	0.18 (0.15, 0.22)	937	1.36	0.11 (0.10, 0.12)

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Table 1: Suicide deaths and rate (per 100,000) across different groups in Australia (1986-2005, continued)

Population group	Age group			35 to 54			55 to 74			75 & over			All ages		
	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)	Cases	Rate	Rate Ratio (95% CI)
Rural/remote areas															
Firearms & other explosives	1,044	5.95	0.47 (0.44, 0.50)	877	4.69	0.37 (0.35, 0.40)	680	6.00	0.48 (0.44, 0.51)	214	6.39	0.51 (0.44, 0.52)	2,834	4.22	0.33 (0.32, 0.35)
Gases & vapours	527	3.00	0.24 (0.22, 0.26)	823	4.40	0.35 (0.33, 0.37)	270	2.38	0.19 (0.17, 0.21)	62	1.85	0.15 (0.11, 0.19)	1,682	2.51	0.20 (0.19, 0.21)
Hanging	1,525	8.69	0.69 (0.65, 0.72)	884	4.73	0.37 (0.35, 0.40)	375	3.31	0.26 (0.24, 0.29)	123	3.67	0.29 (0.24, 0.35)	2,942	4.38	0.35 (0.33, 0.36)
Solid or liquid substances	275	1.57	0.12 (0.11, 0.14)	429	2.29	0.18 (0.17, 0.20)	174	1.54	0.12 (0.11, 0.14)	58	1.73	0.14 (0.11, 0.18)	939	1.40	0.11 (0.10, 0.12)
Other	240	1.37	0.11 (0.10, 0.12)	210	1.12	0.09 (0.08, 0.10)	187	1.65	0.13 (0.11, 0.15)	58	1.73	0.14 (0.11, 0.18)	695	1.04	0.08 (0.08, 0.09)
<b>By methods and by sex</b>															
Male															
Firearms & other explosives	2,555	4.80	0.38 (0.37, 0.40)	2,123	4.29	0.34 (0.33, 0.36)	1,605	5.99	0.48 (0.45, 0.50)	551	8.16	0.65 (0.60, 0.70)	6,869	3.88	0.31 (0.30, 0.32)
Gases & vapours	2,961	5.56	0.44 (0.42, 0.46)	3,428	6.93	0.55 (0.53, 0.57)	1,091	4.07	0.32 (0.30, 0.34)	324	4.80	0.38 (0.34, 0.43)	7,805	4.41	0.35 (0.34, 0.36)
Hanging	6,267	11.77	0.93 (0.91, 0.96)	4,115	8.32	0.66 (0.64, 0.68)	1,821	6.80	0.54 (0.51, 0.56)	670	9.93	0.79 (0.73, 0.85)	12,963	7.33	0.58 (0.57, 0.59)
Solid or liquid substances	1,301	2.44	0.19 (0.18, 0.20)	1,573	3.18	0.25 (0.24, 0.27)	671	2.51	0.20 (0.18, 0.21)	198	2.93	0.23 (0.20, 0.27)	3,746	2.12	0.17 (0.16, 0.17)
Other	1,975	3.72	0.29 (0.28, 0.31)	1,433	2.89	0.23 (0.22, 0.24)	798	2.98	0.24 (0.22, 0.25)	348	5.16	0.41 (0.37, 0.46)	4,559	2.58	0.20 (0.20, 0.21)
Female															
Firearms & other explosives	240	0.45	0.04 (0.03, 0.04)	162	0.33	0.03 (0.02, 0.03)	69	0.25	0.02 (0.02, 0.03)	5	0.05	0.00 (0.00, 0.01)	479	0.26	0.02 (0.02, 0.02)
Gases & vapours	496	0.94	0.07 (0.07, 0.08)	676	1.36	0.11 (0.10, 0.12)	186	0.66	0.05 (0.05, 0.06)	51	0.46	0.04 (0.03, 0.05)	1,409	0.78	0.06 (0.06, 0.07)
Hanging	1,099	2.07	0.16 (0.15, 0.17)	812	1.63	0.12 (0.11, 0.13)	480	1.71	0.14 (0.12, 0.15)	231	2.08	0.17 (0.15, 0.19)	2,657	1.47	0.12 (0.11, 0.12)
Solid or liquid substances	865	1.63	0.13 (0.12, 0.14)	1,290	2.59	0.21 (0.19, 0.22)	662	2.36	0.19 (0.17, 0.20)	236	2.13	0.17 (0.15, 0.19)	3,061	1.69	0.13 (0.13, 0.14)
Other	542	1.03	0.08 (0.07, 0.09)	616	1.23	0.10 (0.09, 0.11)	421	1.50	0.12 (0.11, 0.13)	163	1.42	0.12 (0.10, 0.14)	1,745	0.97	0.08 (0.07, 0.08)
<b>Total suicide</b>	<b>18,301</b>	<b>17.23</b>	<b>1.36 (1.34, 1.38)</b>	<b>16,228</b>	<b>16.35</b>	<b>1.29 (1.27, 1.32)</b>	<b>7,804</b>	<b>14.23</b>	<b>1.12 (1.10, 1.15)</b>	<b>2,773</b>	<b>15.54</b>	<b>1.23 (1.18, 1.28)</b>	<b>45,293</b>	<b>12.66</b>	

Note: population size (all and by groups) was based on the mean value of Australian population census (1986, 1991, 1996, 2001, 2006). Reference group: annual average of total suicide in Australia between 1986 and 2005 after adjusting for population changes over years.

Table 2: Suicide rate change over time (population groups and suicide methods)

	RR	95% CI	P-value
All suicide	0.99	0.99, 0.99	<0.001
Male	0.99	0.99, 0.99	<0.001
Female	0.99	0.99, 0.99	<0.001
Age 15-34	0.99	0.99, 1.00	<0.001
Age 35-54	1.00	0.99, 1.00	0.009
Age 55-74	0.97	0.97, 0.98	<0.001
Age 75 & over	0.97	0.97, 0.98	<0.001
Urban areas	0.99	0.99, 0.99	0.001
Regional areas	1.00	0.99, 1.00	0.019
Rural & remote areas	1.00	0.99, 1.00	0.022
Firearm	0.93	0.93, 0.94	<0.001
Hanging	1.04	1.03, 1.04	<0.001
Gas and vapour	0.99	0.98, 0.99	<0.001
Solid or liquid substances	0.97	0.96, 0.97	<0.001
Other methods	0.98	0.98, 0.98	<0.001

RR: Relative Risk. Reference group: suicide in 1986 for each population group.

Table 3: Male suicide rate by firearms change over time (Reference: mean annual male suicide rate in 1986-1990 by each of age groups and types of regions)

Population group	Time period	RR	95% CI	P-value
15-34 yrs	2001-2005	0.22	0.08, 0.36	<0.001
	1996-2000	0.39	0.28, 0.51	<0.001
	1991-1995	0.78	0.69, 0.87	<0.001
35-54 yrs	2001-2005	0.39	0.26, 0.51	<0.001
	1996-2000	0.52	0.40, 0.64	<0.001
	1991-1995	0.83	0.72, 0.94	0.001
55-74 yrs	2001-2005	0.43	0.28, 0.57	<0.001
	1996-2000	0.63	0.49, 0.76	<0.001
	1991-1995	0.88	0.75, 1.01	0.049
75 yrs & over	2001-2005	0.45	0.21, 0.69	<0.001
	1996-2000	0.66	0.43, 0.89	<0.001
	1991-1995	0.83	0.59, 1.06	0.103
Capital cities	2001-2005	0.33	0.21, 0.45	<0.001
	1996-2000	0.46	0.35, 0.57	<0.001
	1991-1995	0.78	0.69, 0.88	<0.001
Regional centres	2001-2005	0.32	0.17, 0.48	<0.001
	1996-2000	0.47	0.33, 0.61	<0.001
	1991-1995	0.78	0.65, 0.90	<0.001
Rural and remote areas	2001-2005	0.41	0.29, 0.53	<0.001
	1996-2000	0.61	0.50, 0.72	<0.001
	1991-1995	0.91	0.81, 1.00	0.048

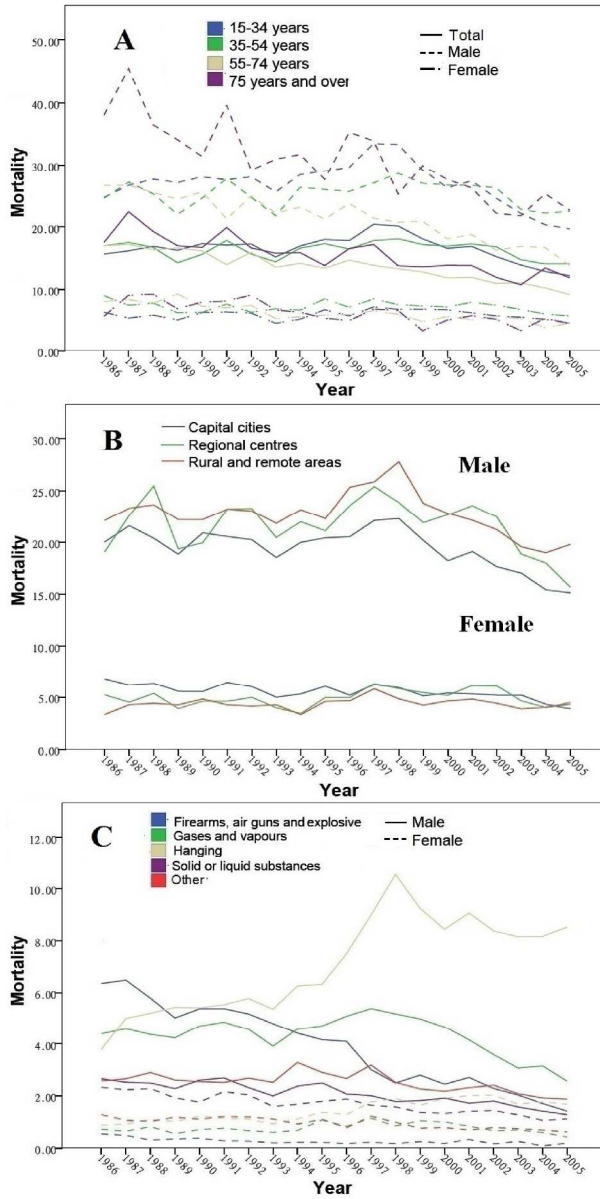


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3 Supplemental 1: Time trend of suicide rates by methods, sexes, age groups and urban/rural  
4 areas (part 1).  
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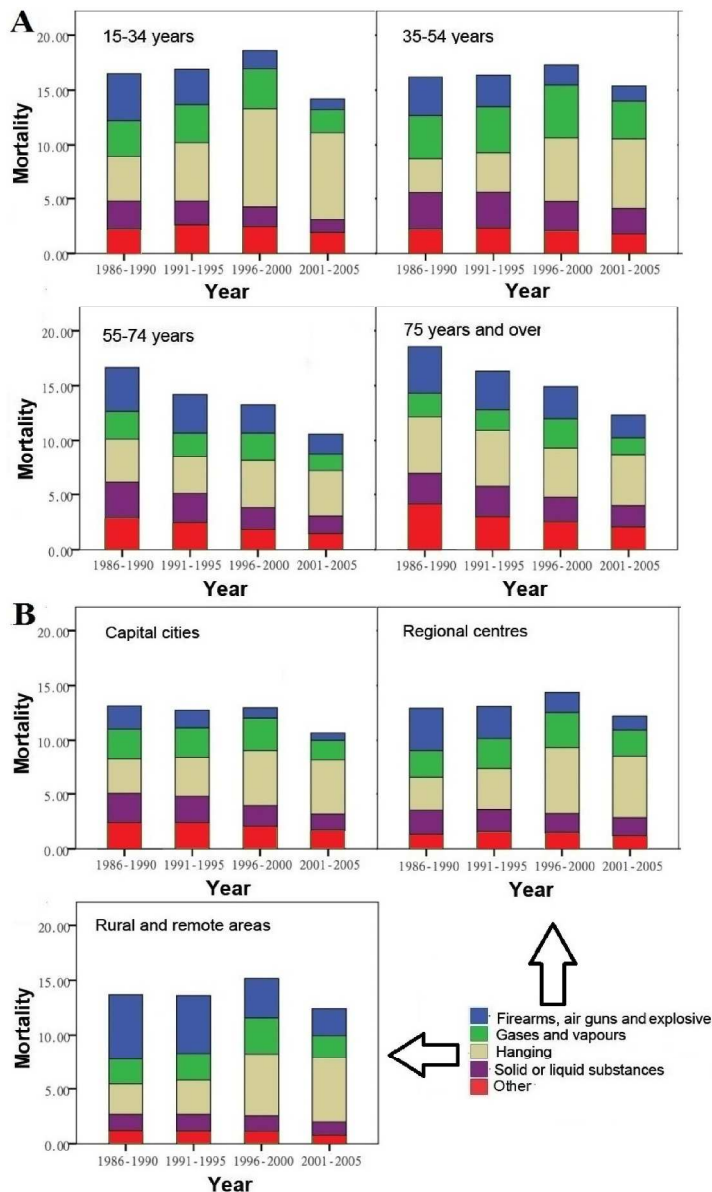
7 Supplemental 2: Time trend of suicide rates by methods, sexes, age groups and urban/rural  
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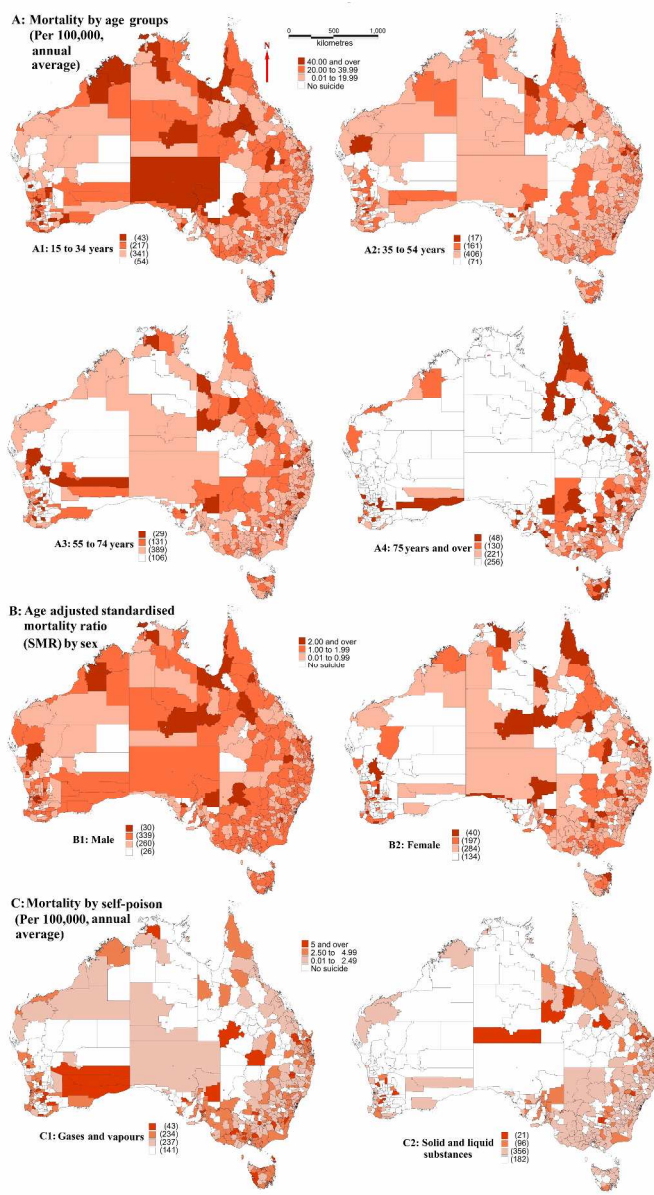
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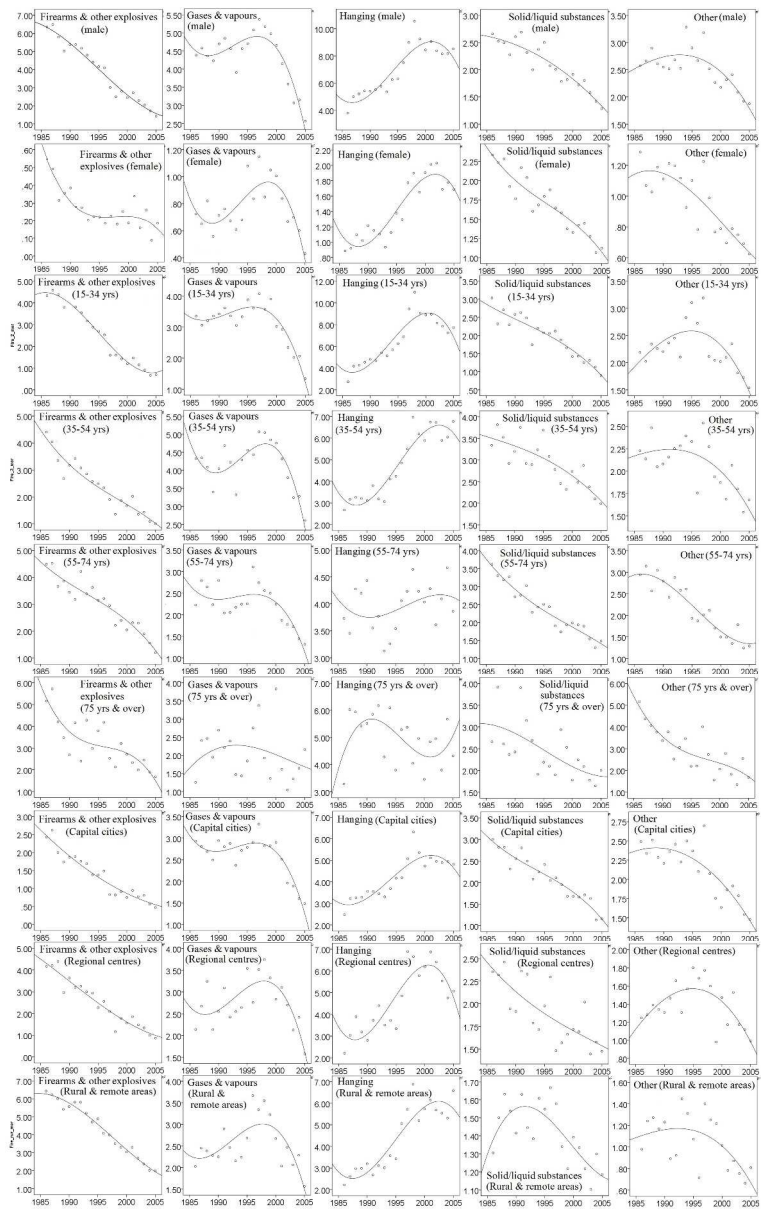
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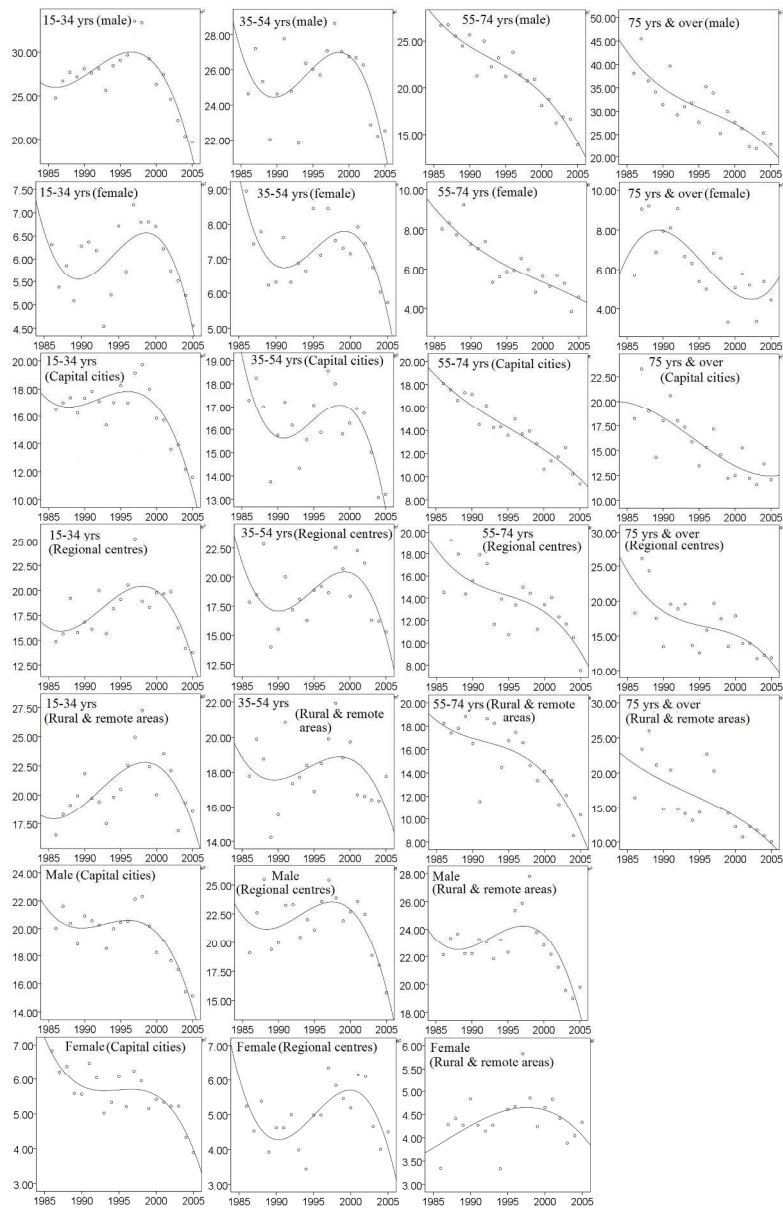
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