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ORIGINAL PAPER

'Hidden' suicides amongst deaths certified as undetermined intent, accident by pesticide poisoning and accident by suffocation in Taiwan

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Abstract
Objective To identify cause-of-death categories in which suicides might be misclassified in Taiwan.
Methods We plotted secular trends (1971–2007) in sex- and method-specific rates of deaths classified as suicide, undetermined intent and accident for the Taiwanese population aged 15+ and compared the sex, age and marital status profiles of deaths in these three categories by method of death.
Results The demographic profiles of registered suicides generally resembled those for deaths of undetermined intent and accidents by pesticide poisoning/suffocation but differed from those for accidents from non-pesticide poisoning/drowning/falling/poisoning by non-domestic gas. For the period 1990–2007, suicide rates based on suicides alone (14.8 per 100,000) would increase by 23, 7 and 1%, respectively, when including deaths of undetermined intent, accidental pesticide poisonings and accidental suffocations.
Conclusions Suicide rates may be underestimated by more than 30% in Taiwan because some suicides are 'hidden' amongst deaths certified as due to other causes.

Keywords Suicide · Cause of death · Classification · Methods · Taiwan

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Introduction

Suicide is a major cause of premature mortality throughout the world and many nations now regard suicide prevention as a public health priority [12, 42]. Reliable estimates of the incidence of suicide and its trend are crucial for evaluating the effect of preventive strategies. However, officially recorded mortality statistics usually underestimates the true burden of suicides because some of them are misclassified as deaths due to other causes [10, 24, 33].

The most commonly used alternative causes of death for missed suicides are 'death undetermined whether accidentally or purposely inflicted' (or 'death of undetermined intent' or 'undetermined death') [2, 24, 33] and accident [18, 34, 38]. The likelihood of misclassifying possible suicides may change over time, and this may bias the estimates of national trends in suicide [11, 27]. Some researchers and governments combine suicides and deaths from these alternative causes in order to better estimate the true incidence of suicide and its trend [6, 12, 15, 30, 31, 39]. However, before adopting such a strategy, it is crucial to evaluate whether suicides are indeed 'hidden' amongst deaths classified as due to these alternative causes.

Some researchers have investigated whether deaths classified as undetermined intent or accident contain 'hidden' suicides by re-evaluating the cause of death based on additional information from sources such as coroner's records, family interviews or hospital files [2, 9, 10, 24, 33]. However, this approach is laborious and can only be applied to a limited sample of cases [16]. An alternative approach is to compare the demographic characteristics of suicides with those of deaths certified as due to causes of death that may be used as alternatives to suicide by officials. If suicides are 'hidden' amongst these deaths from alternative causes, the latter may have a demographic profile similar to that of

certified suicides. National mortality files having information on basic demographics of the deceased could be analysed using this approach. For example, previous studies showed similarities in demographic profiles between suicides and undetermined deaths in Portugal [11] and Slovenia [28], suggesting that some suicides were 'hidden' amongst undetermined deaths in these two countries.

The demographic profiles of suicides may vary according to the method used [4, 6, 10, 24]. For example, in England and Wales, self-poisoning by solid or liquid substances is relatively common amongst females, whereas hanging and carbon monoxide poisoning are favoured by males [6, 10]. Furthermore, the method of death may influence the likelihood that possible suicides are classified as undetermined deaths. It has been repeatedly shown that deaths by hanging/suffocation are more likely classified as suicides, and those by drowning or poisoning using solids/liquids are more likely classified as undetermined deaths [10, 23, 24, 31, 33, 35, 40, 43]. For some particular methods of death such as poisoning [3, 5, 34] or drowning [9, 18, 38], possible suicides may be misclassified as accidents. Therefore, when comparing the demographic profiles between suicide and deaths from the alternative causes, the comparisons should be conducted separately for deaths by different methods. However, most past research fails to adopt this approach [11, 28].

Taiwan, an East Asian country with a population of 23 million, has experienced a 2.2 (female) to 2.9 (male)-fold rise in deaths certified as suicide since the early 1990s [47]. Rates of deaths certified as undetermined intent increased almost ten-fold during the same period [25]. Previous studies conducted in eastern and southwest Taiwan suggest that 26–44% of suicides, particularly those by poisoning and drowning, were misclassified as accidents in official statistics [7, 14, 44]. Another study found that the majority of poisoning mortality involving pesticide was suicide [41], suggesting that a number of deaths officially certified as accident by pesticide poisoning in Taiwan might be missed suicides.

The aim of this study is to compare the secular trends and sex, age and marital status profiles of deaths certified as suicide, undetermined intent and accident in Taiwan, in order to test the hypothesis that undetermined deaths and accidental poisonings (particularly those involving pesticides)/drownings resemble suicides more closely than other accidental deaths.

Methods

Data sources

Electronic mortality data files for deaths aged 15 and above were provided by the Department of Health, Taiwan, for the period 1971–2007. The files include all deaths in Taiwan and are based on the death certificate, which records demographics including age, sex and marital status, the cause of death and the manner of death (death from illness; accident; suicide; homicide; and undetermined). Taiwanese law requires that, if there is any doubt or suspicion of an unnatural death (death due to causes other than illness, i.e. death from accident, suicide or homicide), the case should be referred to the prosecutors' office for a medico-legal investigation into the cause of death [29]. If the intent cannot be determined, death of undetermined intent is certified.

Based on information from the death certificates, the coders at the Department of Health assign a code for each death according to the rules of the International Classification of Diseases (ICD). Two revisions of the ICD have been used during the study period—ICD-8 [45] for the period 1971–1980 and ICD-9 [46] for the period 1981–2007. We investigated secular trends and the demographic characteristics of suicides, undetermined deaths and accidental deaths by five consistently coded methods (Table 1): poisoning by solid or liquid substances; poisoning by other gases (gases other than domestic gas); hanging/suffocation;

Table 1 Three-digit ICD E-codes for suicide, death by undetermined intent and accidental death by method of death

Method of death	ICD-8 (1971–1980)			ICD-9 (1981–2007)		
	Suicide	Undetermined intent	Accident	Suicide	Undetermined intent	Accident
Poisoning by solid or liquid substances	950	980	850–869	950	980	850–866
Poisoning by pesticides			865			863
Poisoning by non-pesticides			850–864, 866–869			850–862, 864–866
Poisoning by other gases	952	982	873–877	952	982	868–869
Hanging/suffocation	953	983	913	953	983	913
Drowning/submersion	954	984	910	954	984	910
Jumping/falling	957	987	880–887	957	987	880–888

Suicide and undetermined death by pesticide poisoning are only identifiable by four-digit ICD codes

drowning; and jumping/falling. We also analysed deaths from accidental poisoning separately for those which involved pesticides or substances other than pesticides (non-pesticides). In Taiwan, suicides by 'other gas' poisoning are mostly due to carbon monoxide poisoning using charcoal burning [20]. During the study period, these five methods were the most commonly used for suicide, accounting for 91–96% of recorded suicides each year.

Mid-year population data were obtained from the Demographic Yearbook published by the Ministry of the Interior, Taiwan.

Data analyses

Sex- and age-/method-specific rates of deaths certified as suicide, undetermined intent and accident were calculated. Age-standardised rates were computed based on the world standard population, 2000 [1]. Trends in suicide and undetermined death as well as undetermined death:suicide (U/S) rate ratios were examined. We also compared trends in suicide, undetermined death and accidental death by the five different methods of death.

We compared the sex, age and marital status profiles of certified suicides with those of deaths certified as undetermined intent or accident. The comparisons were conducted separately for the periods 1971–1989 and 1990–2007, because the use of the undetermined death category increased substantially only after 1990; for the period 1971–1989, the comparisons were only conducted between suicides and accidental deaths since deaths of undetermined intent were only rarely certified during the period. All comparisons were conducted separately for the five different methods of death. The male:female sex ratios and marital status profiles of age-standardised rates, and the patterns of rate ratios across different age groups (15–24, 25–44, 45–64 and 65+ years old; with 15–24 years old as the reference group) were compared between deaths certified as suicide, undetermined death and accident.

We further compared the demographic characteristics of accidental deaths by pesticide and non-pesticide poisoning with those of suicides by solids/liquids poisoning, in order to evaluate whether accidental pesticide poisonings resembled suicides more closely than did accidental non-pesticide poisonings.

Results

There were 34,230 suicides, 433 undetermined deaths and 44,146 accidental deaths for the period 1971–1989 in Taiwan; the corresponding figures for 1990–2007 were 41,785, 7,611 and 44,324, respectively.

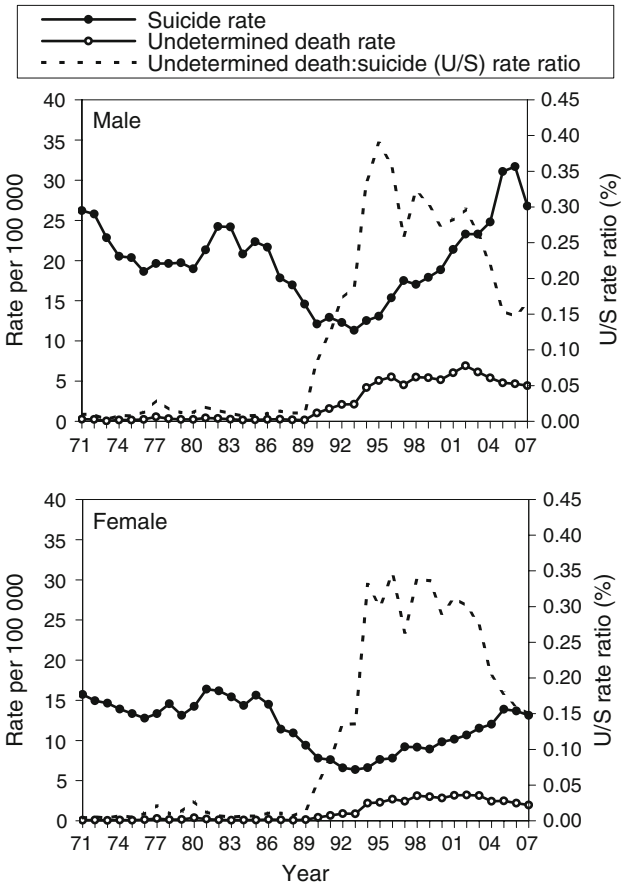

Fig. 1 Trends in rates of suicide and undetermined death and undetermined death:suicide (U/S) rate ratios for males and females in Taiwan, 1971–2007

Trends in suicide, undetermined death and accidental death

Suicide rates for males and females generally declined before 1990 but rose considerably during the 1990s (Fig. 1). Rates of undetermined death were very low before 1990, but increased markedly during the 1990s till reaching a peak in 2002. The rate ratios for undetermined death: suicide deaths rose from less than 0.03 before 1990 to a high of 0.39 for males in 1995 and 0.35 for females in 1996, remained at a level of around 0.30 till 2002, and subsequently fell to 0.17 for males and 0.15 for females by 2007.

Figure 2 shows trends in suicide, undetermined death and accidental death according to the method of death. Rates of suicide and undetermined death both rose during the 1990s irrespective of the method of death. In contrast, trends in accidental death varied for different methods. For poisoning by solids/liquids, rises in suicides and undetermined deaths during the 1990s appeared to coincide with a decline in accidental deaths. Similar patterns were

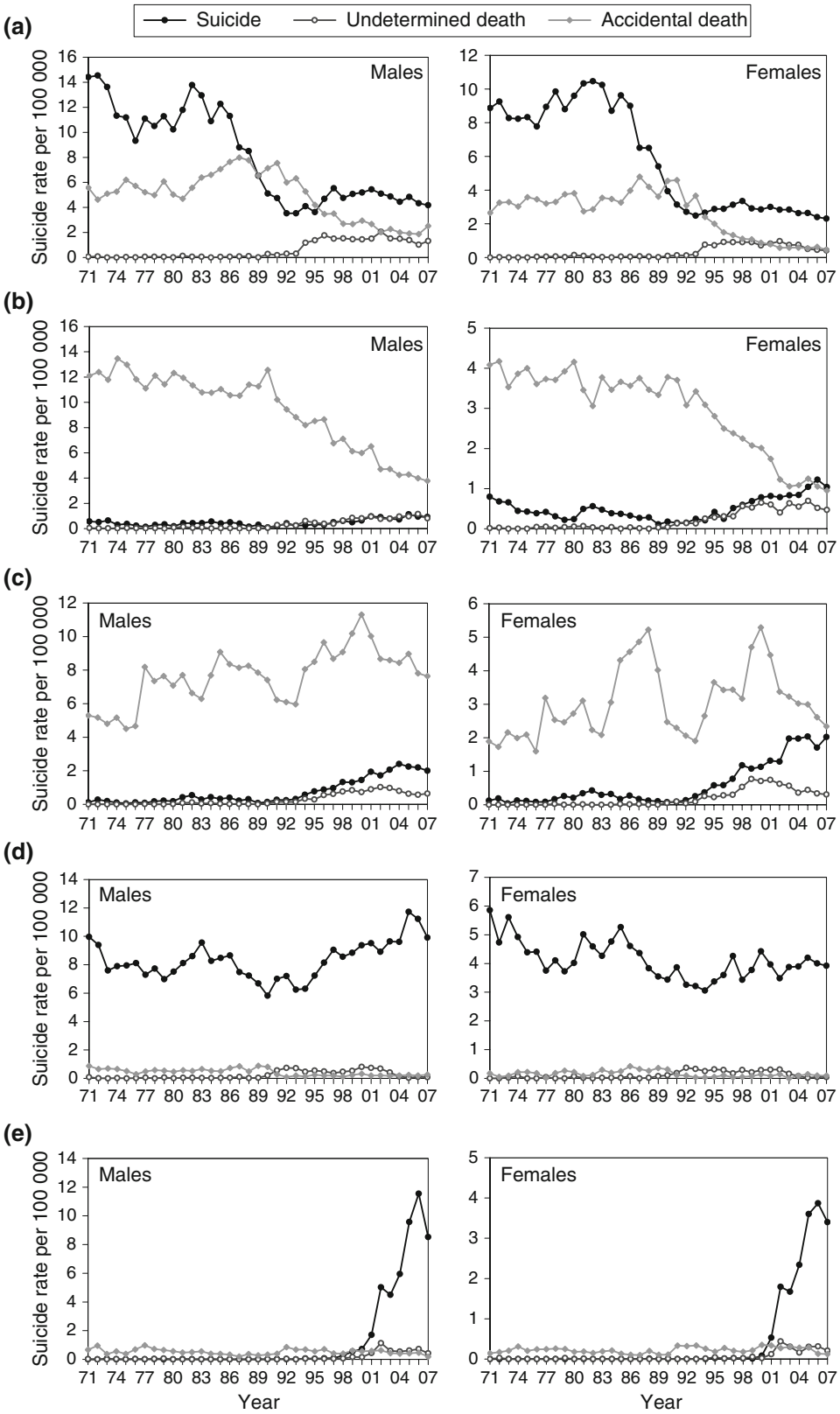

Fig. 2 Trends in suicide, undetermined death and accidental death for males and females by method of death, Taiwan, 1971–2007. **a** Poisoning by solid or liquid substances, **b** drowning, **c** jumping/falling, **d** hanging/suffocation, **e** poisoning by other gases

observed for drowning, but the magnitude of reduction in accidental drownings was considerably larger than that of the rises in suicides and undetermined deaths from this cause. Suicides and undetermined deaths by jumping/falling were uncommon before 1990 but increased markedly during the 1990s, compared to the rather fluctuating rates

of accidental deaths from falls throughout the study period. Decreases around 1990–1991 in deaths classified as accidental suffocations appeared to coincide with a rise in undetermined deaths by hanging, although the numbers of deaths in these two categories were much smaller than those for suicides by hanging. A striking feature of trends in suicide by other gas poisoning was a rapid rise after 1999 for males and after 2001 for females, with a parallel small rise in undetermined deaths by the same method. Previous research has shown this to be due to an epidemic of charcoal burning suicide [20, 21].

Decreases in undetermined deaths after 2002 were seen for all methods except drowning. For the period 2002–2007, reductions were most marked for hanging/suffocation (89% in males; 84% in females), followed by other gas poisoning (62%; 52%), solids/liquids poisoning (36%; 57%) and jumping/falling (38%; 51%); in contrast, relatively stable trends were seen for drowning (a small rise of 6% in males and 16% in females).

In summary, suicides and undetermined deaths, regardless of the methods, both increased after 1990, but reductions in rates were noted in deaths classified as accident from poisoning by solids/liquids and drowning during the same period. Therefore, some degree of misclassification of suicides as accidental deaths (prior to 1990) or undetermined deaths (after 1990) seems likely.

Sex ratios

Figure 3 shows the male:female sex ratios for the age-standardised method-specific rates of suicide, undetermined and accidental death for the period 1990–2007. Male rates were generally higher than female rates. On the whole, sex ratios for undetermined deaths resembled suicides more closely than did accidental deaths; the exception was deaths by hanging/suffocation, where sex ratios were similar for deaths in all three categories. Male:female rate ratios were generally highest for accidental deaths, except poisonings by other gases. The difference between suicides and accidental deaths was more distinct for drowning and jumping/falling than for solids/liquids poisoning and hanging/suffocation; findings for the period 1971–1989 were similar (data not shown).

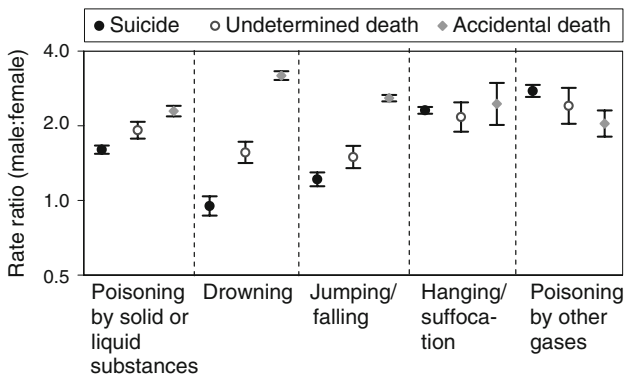

Fig. 3 Male:female ratios of suicide, undetermined death and accidental death rates in Taiwan, 1990–2007, with the vertical bars indicating 95% confidence intervals

Age profiles

For the period 1990–2007, rates of suicide, undetermined death and accidental death generally increased with age regardless of the method of death, with those aged 65+ having the highest rates (Fig. 4). The exception was poisoning by other gases—the incidence of certified suicides and undetermined deaths was markedly higher amongst those aged 25–64 than those aged 15–24/65+, but this pattern was not seen for accidental deaths.

Undetermined deaths generally resembled suicides more closely than did accidental deaths in age patterns, irrespective of the method of death (Fig. 4). Accidental deaths had an age profile generally unlike those observed for suicide, except that accidental deaths by hanging/suffocation, and to a lesser extent poisoning by solids/liquids, had a pattern similar to suicides. Similar patterns were seen for the period 1971–1989; the only exception was accidental death by drowning in females, which showed a pattern similar to suicides (data not shown).

Marital status profiles

The majority of the deaths during the period 1990–2007, regardless of whether they were certified as suicides, undetermined deaths or accidental deaths, were single or married (52–91%); this pattern reflects the marital status distribution in the population. In general, the marital status profiles of undetermined deaths resembled suicides more closely than did accidental deaths, but the differences were slight. The proportion of single people tended to be lowest amongst suicides and highest amongst accidental deaths. The only exception was amongst deaths from jumping/falling; for these the proportion of widows/widowers was higher, and of single people, lower, than that seen for suicides or undetermined deaths, perhaps reflecting the greater risk of accidental falls amongst the frail elderly. Similar patterns were seen for the period 1971–1989 (data not shown).

In summary, compared to certified suicides using the same method, deaths classified as undetermined intent by the five methods studied and accident by suffocation, perhaps as well as accident by solids/liquids poisoning, showed similar patterns in sex, age and marital status profiles. This suggests that there were 'hidden' suicides amongst deaths from these alternative causes. For the

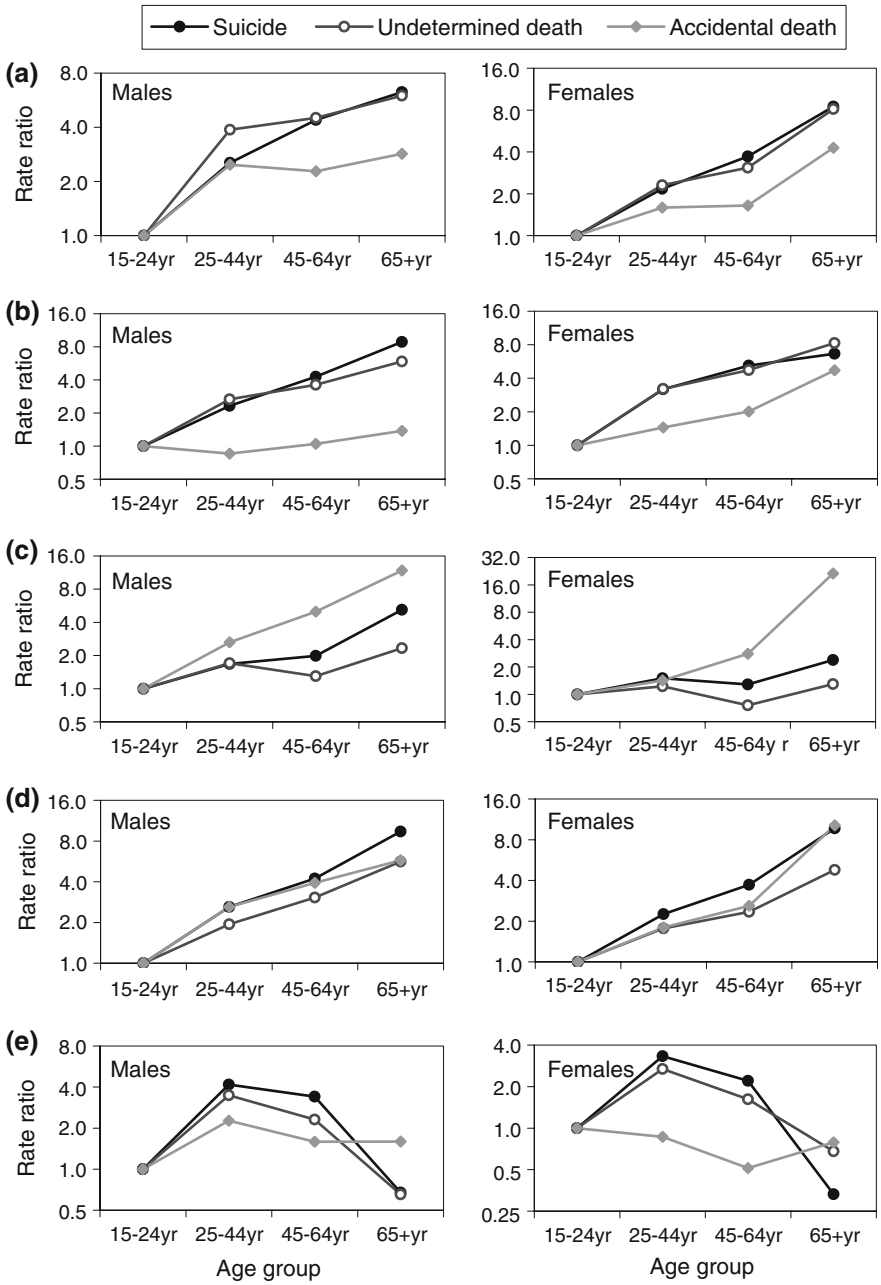

Fig. 4 Rate ratios of suicide, undetermined death and accidental death rates (reference group: 15–24 years old) in Taiwan, 1990–2007. **a** Poisoning by solid or liquid substances, **b** drowning, **c** jumping/falling, **d** hanging/suffocation, **e** poisoning by other gases

period 1990–2007, suicide rates based on registered suicide alone was 14.8 per 100,000; this would increase by 23% to 18.3 per 100,000 when including deaths classified as undetermined intent. In contrast, suicide rates for the period 1990–2007 would increase by only 1% when including accidental deaths by suffocation.

Suicides versus accidental deaths by pesticide or non-pesticide poisoning

During the study period 1971–2007, 48.4% (8,575/17,731) of all certified accidental deaths by solids/liquids poisoning were due to pesticide poisoning. Figure 5 shows the demographic profiles of certified suicides by solids/liquids poisoning in comparison with those classified as accidental poisonings using pesticides or substances other than pesticides. For sex ratios, accidental pesticide poisonings resembled suicides more closely than did accidental non-pesticide poisonings (Fig. 5a). Accidental pesticide poisonings and suicides showed a similar pattern in age and marital status profiles (Fig. 5b, c); in contrast, age and marital status profiles for accidental non-pesticide poisonings differed markedly from those for suicides. Therefore, a considerable proportion of deaths certified as accidental pesticide poisonings could be missed suicides. The addition of accidental deaths by pesticide poisoning would increase

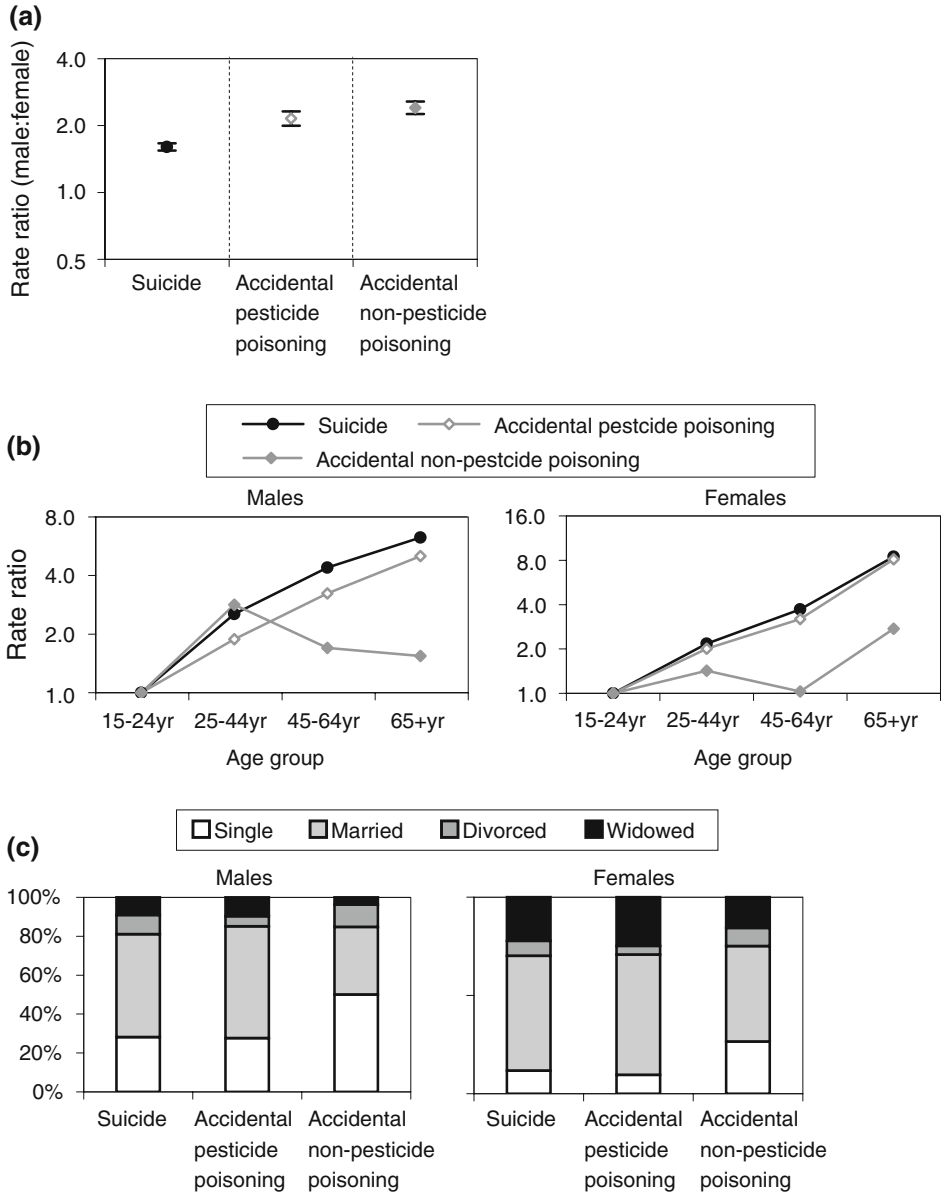

Fig. 5 Demographic profiles of suicides by solids/liquids poisoning, accidents by pesticide poisoning and accidents by non-pesticide poisoning in Taiwan, 1990–2007: **a** sex ratios, **b** age profiles and **c** marital status profiles

the suicide rates based on certified suicides alone for the period 1990–2007 by 7%.

Discussion

The socio-demographic similarities in method-specific death rates suggest that suicides are 'hidden' amongst deaths classified as undetermined intent, accident by pesticide poisoning and accident by suffocation in Taiwan. For the period 1990–2007, the age-standardised suicide rates were 14.8 per 100,000 (19.6 for males; 9.8 for females) based on registered suicide alone; the figures rose by 23% to 18.3 per 100,000 (24.2 for males; 12.1 for females) when including undetermined deaths and by a further 8% to 19.6 per 100,000 (26.0 for males; 12.9 for females) when additionally including accidental deaths by pesticide poisoning and suffocation. The results help clarify which cause-of-death categories may contain a number of 'hidden' suicides in Taiwanese official statistics, and this is crucial to obtain a reliable estimate of the incidence of suicide in Taiwan.

Strengths and limitations

To our knowledge, this is the first study in Asia to systematically compare the demographic characteristics of registered suicides with those of deaths certified as due to causes which may be used to categorise possible suicides. An important element of the study is to conduct analyses

separately for different methods of death since the demographic profiles differ considerably between suicides using different methods.

The study has several limitations. Firstly, not all certified deaths of undetermined intent and accidental pesticide poisoning/suffocation are likely to be suicides [2, 24]. The aim of this study was not to verify whether every death in these categories is a true suicide or not, but to obtain a more reliable estimate of the incidence of suicide and its trend and to identify whether the reliability of official estimates may be improved upon. A clinical study collecting additional information on the deceased and the circumstances of death is needed to fully evaluate the validity of suicide statistics. Secondly, we are limited in the information available in the mortality files. Other information sources such as psychiatric treatment records or forensic reports may be valuable but are more difficult to obtain. Finally, we compared the demographic features of suicides by solids/liquids poisoning with those of accidental pesticide poisonings, but not all suicides by solids/liquids poisoning used pesticide. Taiwanese mortality files contain only three-digit ICD codes and therefore do not allow the identification of suicides by pesticide poisoning (ICD-9 E950.6). However, past research in Taiwan based on Poison Control Centre data [22, 48] and emergency department files [19] shows that the majority of poisoning deaths (73-92%) are suicides and most of these deaths (73–83%) are from pesticide ingestion.

'Hidden' suicides amongst undetermined deaths

The number of deaths classified as undetermined intent increased markedly after 1990 in Taiwan and the reasons for such a change are not clear. In other countries, sudden rises in registered undetermined deaths and corresponding decreases in registered suicides were related to the introduction of ICD-8 [17, 27, 32], in which the category of 'undetermined death' was first used. However, in Taiwan, the rise in registered undetermined deaths during the 1990s post-dated the introduction of ICD-8 in 1971 and the transition to ICD-9 in 1981. Past research suggests that the biased certification practices of a small number of medical examiners/coroners [26] and changes in their attitudes and practice in deciding what causes of death are recorded onthe death certificates (personal communication with Professor A.T.A. Cheng) may have led to increased use of the undetermined death category. Nevertheless, further research is needed to better understand Taiwanese certifiers' operational criteria used for certifying suicides and the potential sources of errors.

Undetermined death:suicide (U/S) rate ratios varied noticeably for different methods of death. In fact, when the overall U/S rate ratios reached a peak in 1995, method-specific U/S rate ratios ranged from 1.40 in males and 0.68 in females for drowning to 0.08 and 0.09 for hanging. This suggests that the certifiers based their decisions on suicidal intent according to the method of death—deaths by hanging were much more likely to be certified as suicide than were deaths by drowning, a finding in keeping with that seen in other countries [10, 23, 24, 31, 33, 35, 40, 43].

'Hidden' suicides amongst accidental deaths

Our results indicate that a considerable proportion of the certified accidental pesticide poisonings were likely to be missed suicides. This is in keeping with findings from previous studies. The only psychological autopsy study conducted in Taiwan found 39% of suicides by poisoning were missed in the official statistics [14], and most of them involved pesticides and were misclassified as accidents (personal communication with Professor A.T.A. Cheng). Past research in Taiwan using data from the Poison Control Centres [22, 48] or the emergency department [19] shows that the majority of poisoning deaths are suicides using pesticides. In a clinical study based on hospitalized patients in northwest Taiwan, accidental death from pesticide poisoning is rare—amongst 42 poisoning deaths involving pesticides only one was thought to be accidental [41].

The recent reduction in deaths classified as accident by pesticide poisoning coincided with a rise in registered suicides and undetermined deaths by poisoning. This suggests that suicides by pesticide poisoning might be increasingly correctly certified as suicides or misclassified as undetermined deaths rather than accidental deaths.

Although past research in southern Taiwan [44] and other countries [9, 18, 38] suggests that suicides were 'hidden' amongst accidental drownings, we found no evidence for this. The population in Taiwan has easy access to water, either the sea or rivers, since Taiwan is an island country located in a subtropical area. This could explain the relatively large number of deaths from accidental drowning and mask the characteristics of 'hidden' suicides, if any, amongst them.

The impact of 'hidden' suicides

The impact of 'hidden' suicides on estimating the incidence of suicide and its trend depends on the alternative causes of death included in the estimations. Age-standardised suicide rates based on certified suicides alone for the period 1990–2007 would rise by 23, 7 and 1%, respectively, if registered deaths of undetermined intent, accidental pesticide poisoning and accidental suffocation were included.

Previous research has shown that the magnitude of the rise in suicide in Taiwan between 1993 and 2005 is similar

either when the estimates are based on registered suicides alone (2.9-fold increase in males and 2.2-fold increase in females) [47] or when combined suicide and undetermined deaths are used (2.7-fold increase in males and 2.3-fold increase in females) [21]. Further inclusion of accidental deaths by pesticide poisoning and suffocation somewhat reduces the relative magnitude of the rise—the increases would become 2.2-fold and 1.8-fold for males and females, respectively. This indicates that the recent rise in suicide in Taiwan is not an artefact due to changes in the classification of deaths by suicide; in contrast, changes in the practise of classifying suicides were found to bias the national trends in suicide in Portugal [11] and Malaysia [27].

Implications of the findings

Future epidemiological studies of suicide using the Taiwanese national mortality data files, including time trend analysis, should consider the impact of 'hidden' suicides amongst deaths classified as undetermined intent and accident. When setting suicide reduction targets, Taiwanese national suicide prevention schemes should evaluate the impact of 'hidden' suicides on the national rates derived from the official mortality files. Measures should also be taken to improve the quality of suicide statistics, such as providing education or guidelines to certifying and coding officials [26]. In other countries where there are a considerable number of registered undetermined or accidental deaths in official mortality statistics such as some European [8], Islamic [36], Latin American [37] and Asian countries [27], analytical strategies used in this study may help better understand the reliability of suicide statistics. Our finding that suicides are 'hidden' amongst deaths classified as accidental pesticide poisoning in official statistics has implications for investigating the impact of pesticide regulations on suicide prevention in the regions where many poisoning deaths involve pesticides [13].

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