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ORIGINAL PAPER

The influence of undetermined deaths on suicides in Shanghai, China

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Abstract

Purpose In global forensic practice, some suicides were misclassified as undetermined deaths, leading to suicide underreporting. In this study, we aimed to explore the influence of undetermined deaths on suicides in Shanghai, China.

Methods The police records on suicide verdicts and undetermined deaths in Pudong, Shanghai, from 2004 to 2016 were used. In this study, undetermined deaths have been classified into three levels of suicide possibilities namely, probable, possible, and highly unlikely. Probable suicides were presumed as misclassified suicides. Poisson regression was used to calculate the rate ratio ("RR") of probable suicides compared to suicide verdicts. Poisson regression was also used to calculate the annual percentage change ("APC") of the original suicide rates (crude suicide rates based on the suicide verdicts) and adjusted suicide rates (crude suicide rates based on the suicide verdicts and probable suicides).

Results Among the 1,318 underdetermine deaths, 560 (42.5%) were classified as probable suicides. The overall RR was 0.23 (95% CI 0.21–0.26): 0.15 (0.13–0.17) for the locals' RR and 0.22 (0.19–0.26) for the migrants' RR. The APCs of the original and adjusted suicide rates were − 2.0 (− 3.1 to − 0.9) and − 2.9 (− 3.8 to − 2.0), respectively, for the overall population.

Conclusions The number of suicides could be 23% higher than the reported cases. Suicides were more likely to be underreported in migrants than in the locals. Thus, it is important to improve suicide monitoring and the surveillance systems in China.

Keywords Suicide · Underreporting · Undetermined death · China

Introduction

Although, annually, the Chinese Ministry of Health ("MOH") announced the national mortality rates [1], the MOH suicide rates were believed to be underreported [2]. Comparing the mortality data between the MOH and the Chinese Statistics Bureau, the MOH data were fewer [3]. To combat the differences, Phillips et al. assumed that the "unreported deaths within each cohort" (sex and age cohorts in the MOH data) were "evenly distributed across causes" (all causes of deaths) [3]. After adopting this assumption, they found that the MOH suicide data could underestimate the national suicide rate by approximately 18% during the period from 1995 to 1999 [3]. Phillips et al.'s assumption was adopted by some following-up studies on suicides and other deaths in China [4, 5].

It is the stance of this study that Phillips et al.'s assumption [3] was inappropriate. According to international forensic practice, the misallocation of suicides to unnatural deaths caused by undetermined intent (undetermined deaths) was a key mechanism resulting in suicide underreporting [6]. Therefore, assessing the influence of undetermined deaths is of importance to evaluate the magnitude of underreported suicides [7–9]. However, the rates of undetermined deaths (under the category of external causes of injury or poisoning) had not been reported by the MOH data [1]. Thus, using the MOH data was impossible to show the relationship between undetermined deaths and suicides [3, 4].

Table 1 reviews the international studies on the influence of undetermined deaths on suicides in the all-age general population. Methods for adjusting underreported suicides

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Table 1 International studies on the influence of undetermined deaths on suicides in the all-age general population

Authors	Years published	Sources of data	Study regions	Periods of study	Suicide rates per 100,000 population	Undetermined death rates per 100,000 population	Ratios of suicides/possible underreported suicides
Maniam [17]	1995	Department of Statistics, Malaysia, Vital Statistics	West Malaysia	1996–1990	1.5–7.6	0.2–11.0	0.3–1.3
Wasserman and Varnik [18]	1998	All-Union Statistical Committee, local statistical committees, statistical yearbooks, and demographic yearbooks	Former USSR	1970–1990	18.5–29.7	2.5–8.4	5.3
Ohberg and Lonnquist [15]	1998	National Suicide Prevention Project	Finland	Apr 1987–Mar 1988	28.3	2.8	10
Lindqvist and Gustafsson [19]	2002	Institute of Forensic Medicine in Umea	Vasterbottens County, Sweden	Sep 1983–Dec 1985	17.5	4	4.4
Baumert et al. [20]	2005	Federal Statistical Office	Germany	1991–2012	Male: 22.9–29.8, female: 8.1–12.3	Not specified	5.6
Pritchard and Amanullah [21]	2007	WHO Annual Mortality statistics and UN Year Book	17 Islamic countries	Most recent 3-year period available	Male: 0 (Qatar) to 50.6 (Kazakhstan); female: 0 (Qatar) to 8.9 (Kazakhstan)	Male: 0 (Pakistan) to 42.0 (Qatar); female: 0 (Syria) to 18.7 (Egypt)	Male: 0.003 (Egypt) to 14.3 (Turkey); female: not reported
Chang et al. [13]	2010	Department of Health	Taiwan, China	1971–2007	14.8	Not specified	3.3
Varnik et al. [16]	2011	WHO European mortality database	All European countries	Most recent 5-year period available	Lowest in Greece and highest in Lithuania	Lowest in Greece and highest in Russia	1.2 (Portugal) to 100 (Norway)
Bjorkenstam et al. [7]	2014	Several public national registers	Sweden	1987–2011	Male: 20–34, female: 7–14	Male: 4–11, female: 2–5	3.5
Pritchard and Hansen [14]	2015	WHO Annual Mortality Statistics	Switzerland, Portugal, UK, Denmark, Sweden, Germany, Finland, Canada, USA, Austria, Japan, Ireland, Italy, New Zealand, France, Netherlands, Australia, Norway, Spain, and Greece	2004–2006 (some nations had different years)	Male: 10.6 (UK) to 39.3 (Finland); female: highest 13 (Japan)	Male: 0 (Spain) to 7.9 (Switzerland); female: 0 (Greece) to 4.5 (Switzerland)	Male: 0.9 (UK and Portugal) to nations with no undetermined deaths (Spain and Greece); female: 0.7 (UK) to 68.0 (Norway)
Auger et al. [11]	2015	Canadian Census Mortality Follow-up Study	Nine provinces in Canada	1991–2001	Male: 18.0, female: 5.1	Male: 2.6, female: 0.6	Male: 5.0, female: 4.4
Chan et al. [8]	2015	Population statistics	South Korea, Japan, and Hong Kong	1992–2011 (except Japan 1995–2011)	8.2–26.0 (South Korea); 13.4–18.2 (Japan); 9.2–11.7 (Hong Kong)	1.7–3.4 (South Korea); 5.7–6.9 (Japan); 0.3–2.8 (Hong Kong)	8.6 (South Korea); 14.9 (Japan); 12.3 (Hong Kong)

Table 1 (continued)

Authors	Years published	Sources of data	Study regions	Periods of study	Suicide rates per 100,000 population	Undetermined death rates per 100,000 population	Ratios of suicides/possible underreported suicides
Bakst et al. [9]	2016	All death records in the district of Tel Aviv	Tel Aviv, Israel	2005–2008	7.5	Not specified	2.3

varied among nations/regions. First, in Canada, Spain, Ireland, England, and Wales, all undetermined deaths were assumed as underreported suicides [10–12]. Second, in Taiwan and Greece, except undetermined deaths, some accidental deaths were also assumed as underreported suicides [13, 14]. Third, in Israel and Finland, undetermined deaths were classified by different levels of suicide possibilities and only possible suicides (or probable suicides) were assumed as underreported suicides [9, 15]. By applying the above methods, suicide underreporting was presumed to be minor in nations where the ratios of suicide to possible underreported suicide were high and vice versa [13, 16]. For example in countries with high ratios like Norway and Spain, suicides could be rarely underreported [14]. While, in Malaysia and Egypt, the ratios were low, suicide underreporting could thus be serious [17]. However, to the best of the authors' knowledge, no study has ever explored the influence of undetermined deaths on suicides in Mainland China.

Many undetermined deaths were recorded by the police in Mainland China. For example, in Shanghai, among the unnatural deaths investigated by the Shanghai Metropolis Police during the 1990s ($n=7021$), undetermined deaths ($n=500$) shared about an equal proportion to that of suicides ($n=563$) [22]. During the 2000s, the number of undetermined deaths rose to 1399, while only 429 suicides were recorded in the same period [23]. In light of the ratio of suicides to undetermined deaths being far lower than five [16], the severity of suicide underreporting was indicated [16, 21]. Not only in Shanghai, the police in other Chinese cities also reported undetermined deaths [24]. Therefore, studying the influence of underdetermined deaths on suicides is of great importance in evaluating suicide underreporting in China.

In this study, the police data in Pudong New District (Pudong) of Shanghai were used to explore the influence of undetermined deaths on suicides.

Methods

Pudong is the most populous district of Shanghai, accounting for a quarter of the city population (24 million) [25]. From 2004 to 2016, 2407 suicide verdicts and 4572 open verdicts were recorded. In the police data, open verdicts were classified into three categories, probable natural causes, unknown causes, and undetermined deaths. In the present study, only undetermined deaths ($n=1318$) were included. The third method is used in this report, namely classifying undetermined deaths by different levels of suicide possibilities to estimate underreported suicides [9]. In the current study, the undetermined deaths have been classified into three levels of suicide possibilities namely, probable, possible, and highly unlikely. However, the definition of probable suicide was different in this study. In Bakst et al.'s study,

probable suicides were defined as "definitive suicide cases, albeit not officially certified" [9]. In the present study, however, probable suicides were suicides of high certainty, but still, this cannot be ascertained with certainty. The classification was performed by the first two authors, who were the Chinese police medicolegal physicians.

After the classification, only probable suicides were presumed to be misclassified (underreported) suicides [9]. Individuals were classified by sex, age (15–24 years, 25–44 years, 45–64 years, and 65 years and above), and origin. Referring to the definition of origin, individuals with Shanghai Hukou (place of personal identification registration) were defined as local residents; other Mainland Chinese were defined as internal migrants. The population size was provided by the Pudong Statistics Bureau. From 2004 to 2016, the population grew from 2.7 to 5.5 million [25]. The age composition was based on the data reported in the Six National Census [26]. Due to the expansion of Pudong [25], the population coverage of the police data has changed, and thus, the population in the present study has been adjusted accordingly.

First, the magnitude of underreported suicides has been assessed. For this purpose, Poisson regression models were used to calculate the rate ratio ("RR") of probable suicides compared to suicide verdicts. The overall, sex-specific, age-specific, and origin-specific RRs were then calculated. Next, suicide trends were assessed before and after probable suicides were added. Crude suicide rates were used based on the number of suicide verdicts to estimate the original suicide trend. Crude suicide rates were used based on the combined number of probable suicides and suicide verdicts to present the adjusted suicide trend. The overall, sex-specific, age-specific, and origin-specific original and adjusted suicide trends were then presented. To assess these trends statistically, the annual percentage change ("APC") in mortality rates was estimated by fitting the Poisson regression models [27] for both the RR and the APC models. The annual death number was the dependent variable, and the population size was the offset variable. R (Windows version, 3.5.0) has been used for statistical analyses.

Results

Classification results of suicide possibilities

560 deaths have been classified as probable, 416 deaths as possible, and 342 as highly unlikely. Most probable suicides were related to drowning ($n=422$), followed by jumping ($n=103$) and solid/liquid poisoning ($n=26$). After combining the probable suicides and suicide verdicts as adjusted suicides, probable suicides contributed to 11% (103/935) of adjusted suicides by jumping, 0% (0/825) by hanging, 53% (422/798) by drowning, 11% (26/231) by solids/liquids poisoning, 3% (2/76) by gases poisoning, and 7% (7/102) by other methods.

The incidence rate ratio of suicide verdicts to probable suicides

Table 2 shows the results of the RR and the APC models. The overall RR was 0.23 (95% CI 0.21–0.26). The RR of

Table 2 Results of the RR and the APC models

	Original suicide rates (95% CI)[a]	APC for original suicide rates (95% CI)	RR of probable suicides/suicides (95% CI)	Adjusted suicide rates (95% CI)[a]	APC for adjusted suicide rates (95% CI)
Overall	4.5 (4.4–4.7)	− 2.0 (− 3.1 to − 0.9)	0.23 (0.21–0.26)	5.6 (5.4–5.8)	− 2.9 (− 3.8 to − 2.0)
Sex					
Male	5.0 (4.7–5.3)	− 0.9 (− 2.3 to 0.6)	0.25 (0.22–0.28)	6.3 (6.0–6.6)	− 1.9 (− 3.2 to − 0.6)
Female	4.1 (3.8–4.3)	− 3.5 (− 5.0 to − 1.9)	0.21 (0.18–0.24)	4.9 (4.6–5.2)	− 7.9 (− 11.1 to − 4.6)
Age groups[b]					
15–24 years	2.7 (2.4–3.1)	− 3.4 (− 6.7 to 0.0)	0.39 (0.31–0.50)	3.8 (3.4–4.2)	− 4.5 (− 7.2 to − 1.7)
25–44 years	3.2 (3.0–3.5)	− 1.2 (− 3.3 to 1.0)	0.33 (0.28–0.39)	4.3 (4.0–4.6)	− 3.3 (− 5.0 to − 1.5)
45–64 years	5.2 (4.9–5.6)	− 1.4 (− 3.3 to 0.5)	0.19 (0.15–0.22)	6.2 (5.8–6.6)	− 1.7 (− 3.4 to 0.1)
65 years and above	13.4 (12.4–14.4)	− 0.4 (− 2.4 to 1.7)	0.14 (0.11–0.17)	15.2 (14.1–16.3)	− 1.3 (− 3.2 to 0.5)
Places of origin[c]					
Locals	5.3 (5.0–5.5)	0.6 (− 0.7 to 1.9)	0.15 (0.13–0.17)	6.0 (5.8–6.3)	0.5 (− 0.8 to 1.7)
Migrants	3.3 (3.1–3.5)	− 5.2 (− 7.1 to − 3.3)	0.22 (0.19–0.26)	4.0 (3.8–4.3)	− 6.1 (− 7.7 to − 4.4)

[a]Per 100,000 population

[b]Among the suicide verdicts, 21 victims were between 11 and 14 years old, and one victim's age was unknown. Among the probable suicides, six victims were between 11 and 14 years old and one victim's age was unknown. These cases were excluded

[c]Among the suicide verdicts, 46 victims had an unknown origin and 25 victims were not Mainland Chinese. Among the probable suicides, 152 victims were recorded with an unknown origin and one victim was a foreigner. These cases were excluded

males (0.25, 95% CI 0.22–0.28) was slightly higher than that of females (0.21, 95% CI 0.18–0.24). The RR of internal migrants (0.22, 95% CI 0.19–0.26) was significantly higher than that of the local population (0.15, 95% CI 0.13–0.17). Among the four age groups, the 15–24 years age group had the highest RR (0.39, 95% CI 0.31–0.50), while the 65 years and above had the lowest RR (0.14, 95% CI 0.11–0.17). The RR of the 25–44 years age group (0.33, 95% CI 0.28–0.39), however, was significantly higher than that of the 45–64 years (0.19, 95% CI 0.15–0.22).

The change in suicide trends before and after probable suicides added

Figure 1 records the change in overall crude suicide rates before and after probable suicides were added. Both the original suicide rates (APC: − 2.0, 95% CI − 3.1 to − 0.9) and the adjusted suicide rates (APC: − 2.9, 95% CI − 3.8 to − 2.0) exhibited significant declining trends, with the latter being more obvious.

Figure 2 provides the change in sex-specific suicide rates before and after probable suicides were added. For the females, both their original suicide rates (APC: − 3.5, 95% CI − 5.0 to − 1.9) and adjusted suicide rates (APC: − 7.9, 95% CI − 11.1 to − 4.6) exhibited significant declining trends. As, to the males, the declining trend of their original suicide rates was not significant (APC: − 0.9, 95% CI − 2.3 to 0.6), but after probable suicides were added, the declining trend of the adjusted rates became significant (APC: − 1.9, 95% CI − 3.2 to − 0.6).

Figure 3 shows the change in age-specific suicide rates before and after probable suicides were added. In terms of the original age-specific suicide rates, all the four age groups, 15–24 years (APC: − 3.4, 95% CI − 6.7 to 0.0), 25–44 years (APC: − 1.2, 95% CI − 3.3 to 1.0), 45–64 years (APC: − 1.4, 95% CI − 3.3 to 0.5), and 65 years and above (APC: − 0.4, 95% CI − 2.4 to 1.7) showed declining trends, but none was significant. After adding probable suicides of the corresponding age groups, two of the four age groups, namely the trends for 15–24 years (APC: − 4.5, 95% CI − 7.2 to − 1.7) and 25–44 years (APC: − 3.3, 95% CI − 5.0 to − 1.5) were declining significantly.

Figure 4 depicts the change in origin-specific suicide rates before and after probable suicides were added. For the local people, both their original suicide rates (APC: 0.6, 95% CI − 0.7 to 1.9) and adjusted suicide rates (APC: 0.5, 95% CI

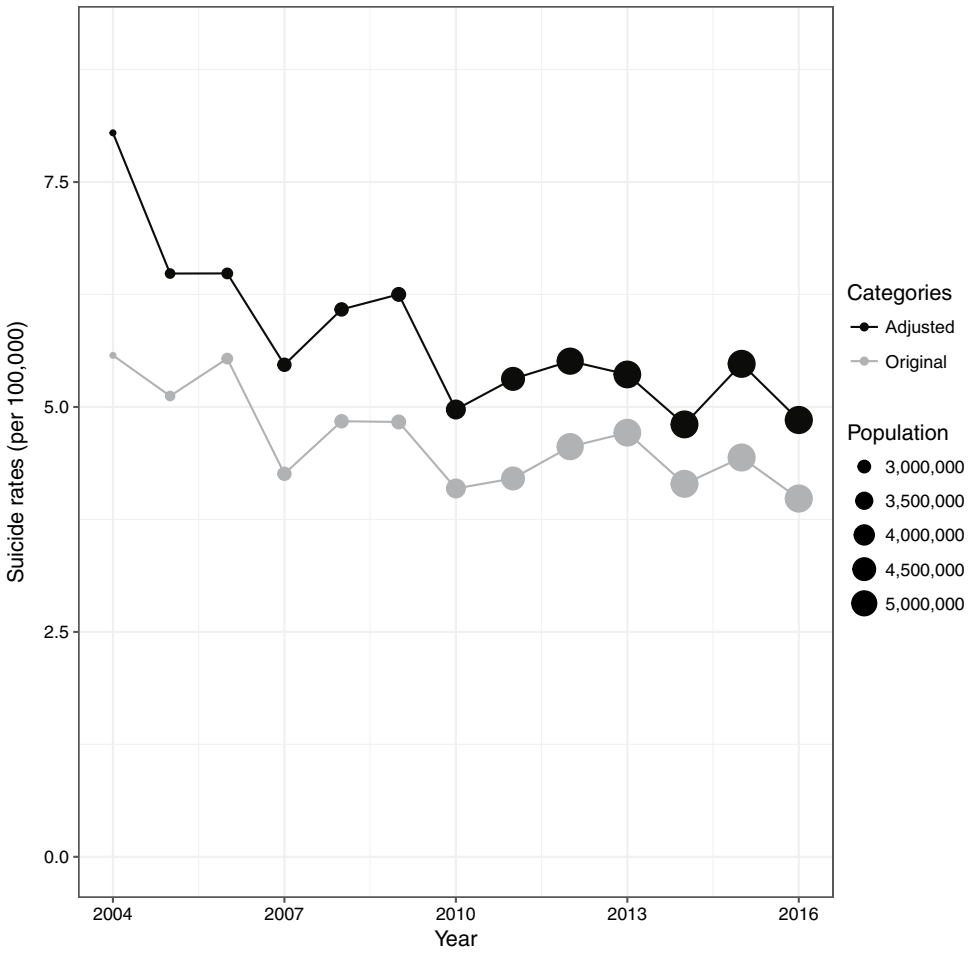

Fig. 1 Change in overall suicide rates before and after probable suicides added

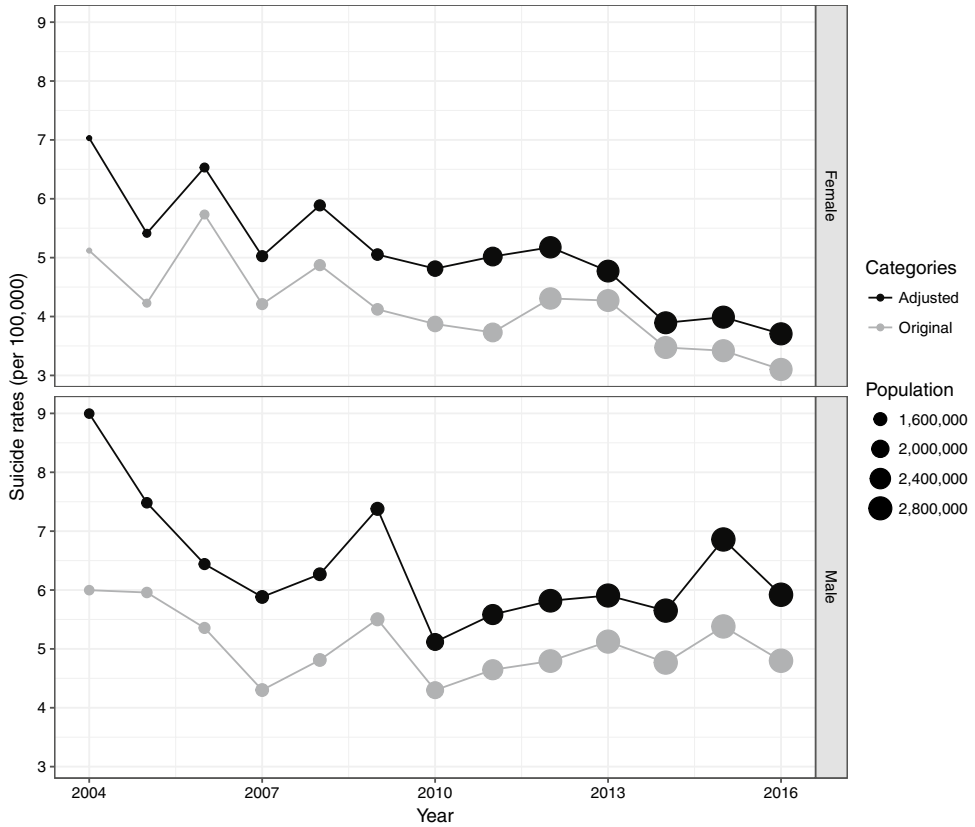

Fig. 2 Change in sex-specific suicide rates before and after probable suicides added

− 0.8 to 1.7) indicated slight increasing trends. By comparison to the internal migrants, both their original suicide rates (APC: − 5.2, 95% CI − 7.1 to − 3.3) and adjusted suicide rates (APC: − 6.1, 95% CI − 7.7 to 4.4) indicated significant declining trends.

Discussion

During the classification process, we found that deaths caused by drowning were frequently misclassified, followed by jumping, and solid/liquid poisoning. By contrast, deaths related to gases poisoning and hanging were rarely misclassified. Therefore, the underestimation of suicides could be related to suicide methods. The present findings were consistent with those in other nations [9, 15]. However, the results failed to support the assumption that less violent methods (e.g., gases' poisoning) were more likely to be misclassified than more violent methods (e.g., jumping) [9]. As a matter of fact, it is discovered that gases poisoning could rarely be misclassified, as the purchase records of flammable materials could be traced, doors and windows could be sealed from inside, and all of the above evidence proved the suicidal intents. However, suicides by gases poisoning were not popular in Israel [9], and thus, the assumption which applied to Israel was not suitable to Shanghai.

As the overall RR of probable suicide to suicide was 0.23 (95% CI 0.21–0.26), this suggested that the adjusted suicide number could be 23% higher than the number of suicide verdicts. Notably, suicide underreporting was not equally distributed among population groups of different sex, age, and place of origin, and thus, the present results contradicted Phillips et al.'s assumption [3]. In particular, the present study found that suicides in people aged 15–44 years were significantly more likely to be underestimated than those aged 45 and above. Furthermore, suicides in internal migrants were significantly more likely to be underestimated than their local counterparts. Assuming that Phillips et al.'s method in adjusting the underreported suicides [3] has been adopted in Shanghai, suicide rates in old people could be exaggerate, while the rates in young people underestimated.

It should further be emphasized that people of unknown origin accounted for 27% (152/560) of probable suicides. Among those people, most had an unknown identity (118/152). In the opinion of the authors, due to lack of social connections, people with unknown identity were more likely to be internal migrants than local residents. Thus, suicide underreporting among internal migrants could be more serious than the results calculated in this study (about 22%). Another concern was that the MOH data were based on collecting death certificates [28], it is very likely that no person asked for and submitted death certificates regarding

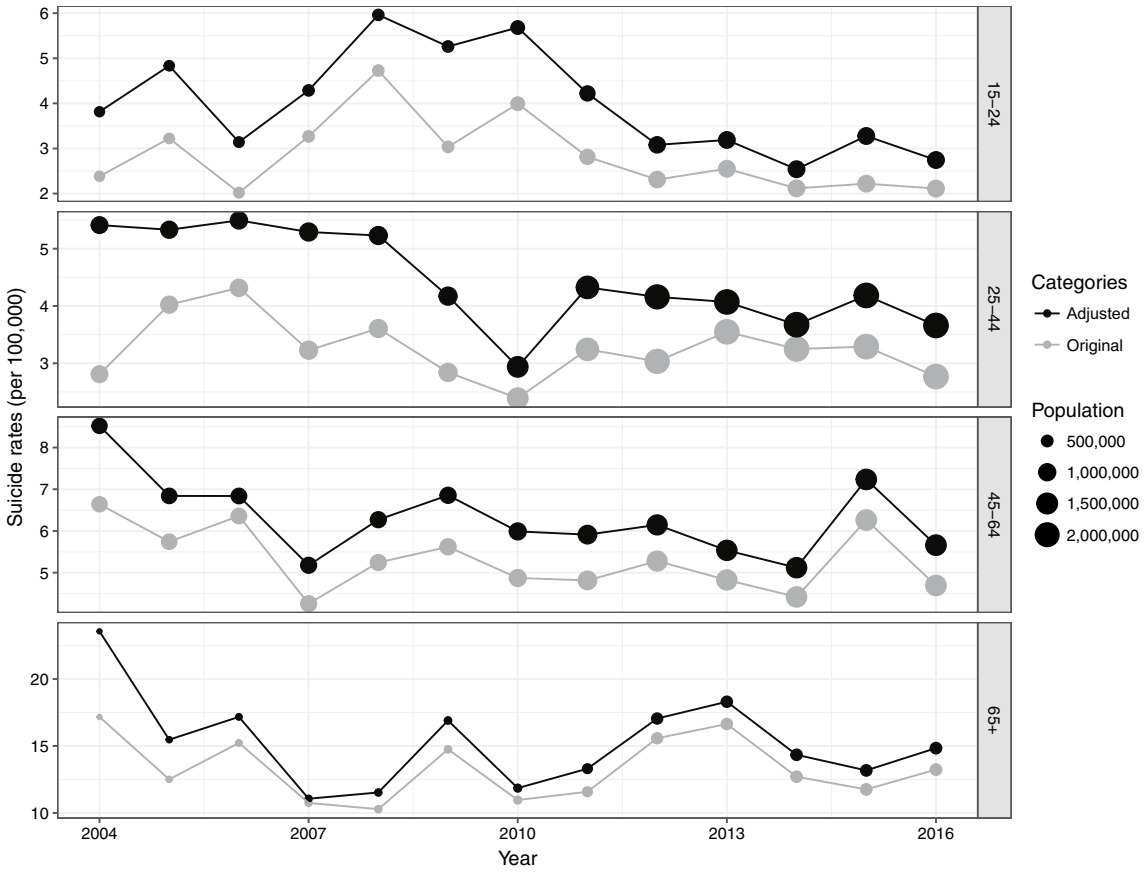

Fig. 3 Change in age-specific suicide rates before and after probable suicides added

unidentified bodies, and thus, the MOH data could well have overlooked those deaths.

For the overall population and most sub-populations, adding underreported suicides made the declining suicide trends more obvious. The local population, however, was the only sub-population that exhibited slight increasing trends in their original and adjusted suicide rates. An assumption has been made that aging could be the most important reason. With the low birth rate in Shanghai, the local population was aging [26]. In addition, the present results showed that older people had higher suicide risks compared with younger people. Despite suicide risks of all the four age groups were declining, the aging problem counteracted the beneficial effects and slightly increased the suicide trends of the local people.

In this study, the undetermined death rate was 2.5 per 100,000 population and the ratio of suicide to undetermined death was 1.8. According to the "2–20 benchmark" (undetermined death rate exceeds 2 per 100,000 population and the ratio of undetermined death to suicide exceeds 20%) in evaluating the "suicide registration quality" [16], the above results suggested that the suicide statistics in Shanghai might not be satisfactory. It is presumed that a low autopsy rate could be an important reason, resulting in the low "suicide registration quality". The police in China have the authority to perform compulsory forensic examinations (including autopsies) in homicides. However, when homicide possibility was excluded, the police had to acquire consents from relatives of the deceased to perform forensic examinations (excluding unidentified bodies). Death without a complete body (死无全尸) was a taboo for most Chinese people; therefore, the autopsy rate was low in China [24]. In Portugal, the autopsy rate and the ratio of suicide to undetermined death were also low [14, 29]. Since autopsies collected essential evidence in judging the manner of death [30], a low autopsy rate could increase the possibility of classifying suicides as undetermined deaths.

Suicide underreporting in Shanghai, however, might not be representative of the national level. China is a nation with diverse landscapes. Shanghai is a metropolis located in southern China, covering large water surface and many high-rise buildings, and thus, deaths caused by drowning and fall were common. However, for northern rural China, water coverage is small and a few high-rise buildings exist, and hence, impeded deaths caused by drowning and fall [31]. Nevertheless, by investigating into possible

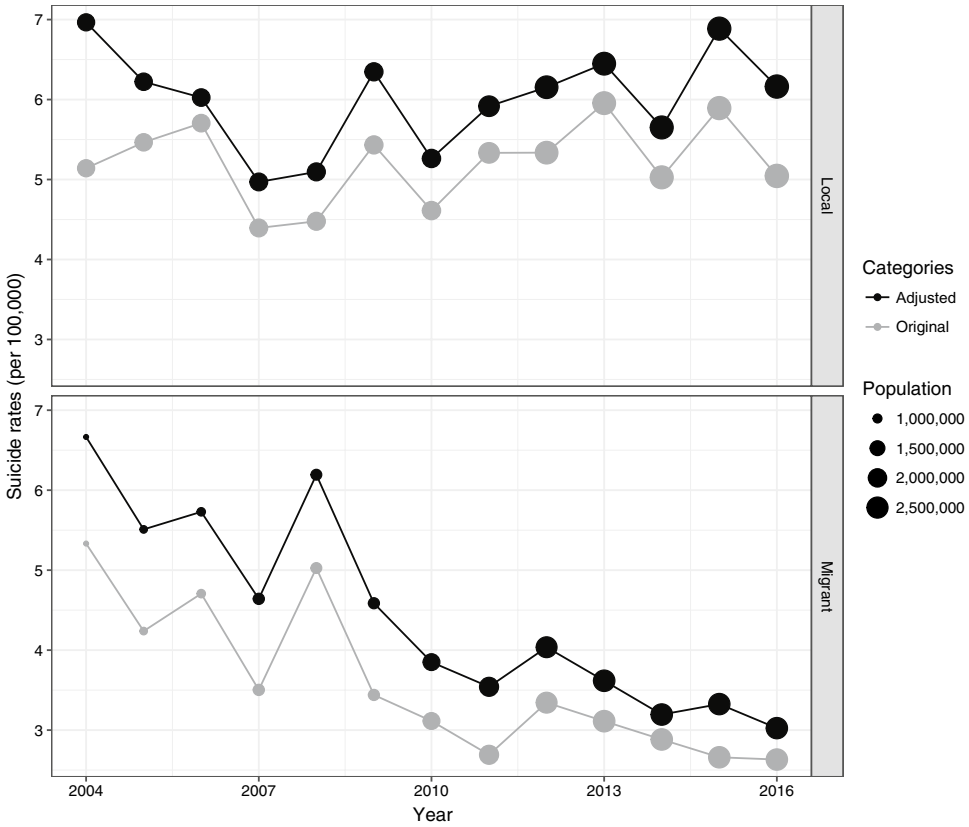

Fig. 4 Change in origin-specific suicide rates before and after probable suicides added

misclassified suicides, this study provided an initial understanding as to how undetermined deaths influence suicides in a mega city of Mainland China.

To improve on the reliability of the MOH suicide data, the following suggestions could well be considered. Unlike Sweden which has nationwide data and background variables [7], data in China are kept by separate government agencies. For example, medical records are recorded by the health departments, marital status recorded by the civil departments, job information, and personal income recorded by the tax departments. As, to the police departments, albeit possible, it is hard to collect all the above information in every unnatural death. Thus, efficient communication among government agencies may facilitate the police to judge the manner of death. Furthermore, misclassification might happen during the transfer of the death certificates. Thus, direct electronic data transmission between the police and the health departments may be useful to decrease misinterpretation of information. In addition, the coding staff affiliated with the health departments may need training in coding unnatural deaths. Due to different suicide methods which have different degrees of underestimation [9], as well as knowing the suicide methods could be useful for suicide prevention [32], hence, it could be helpful if the MOH data include suicide method information [1].

A key limitation of this study, however, is the classification of suicide possibilities. On one hand, it is impossible to guarantee that probable suicides (e.g., falls happened among people with major depression) were definitive suicides. On the other hand, it is also impossible to guarantee that highly unlikely suicides (e.g., children under 7 years old might have self-harm behaviors and eventually died [33]) were not suicides. Thus, it is inevitable that classification suffered subjective bias. Another limitation is that a conservative method was used in estimating underreported suicides [9]. In this method, open verdicts due to probable natural causes and unknown causes were excluded ($n = 3254$). Undetermined deaths classified as suicide highly unlikely and possible were also excluded, so were all accidental deaths. As some of those deaths might be misallocated suicides [9, 13], therefore, the number of underreported suicides could increase if those deaths were taken into consideration.

Author contributions XL had full access to all the data in the study and takes responsibility for the integrity and the accuracy of the data. Concept and design: FL and XL. Drafting of the manuscript: all authors.

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Compliance with ethical standards

Conflict of interest All authors declare that we have no conflict of interest.

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