


# BMJ Open Trends of injury mortality during the COVID-19 period in Guangdong, China: a population-based retrospective analysis

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## ABSTRACT

**Objective** We aimed to ascertain the trends of injury mortality during the COVID-19 period in southern China.

**Methods** We conducted a population-based retrospective analysis to compare the mortality changes of all-cause injury and transport injuries, poisoning, falls, fire/heat/hot substances, drowning, self-harm and interpersonal violence, which were further stratified by sex and age. Comparisons were made between the COVID-19 period (between January 2020 and June 2020) and control period (between January 2019 and June 2019) in Guangdong province. We used the negative binomial models to explore the associations of deaths during the COVID-19 period, according to the different sex and age strata.

**Results** The all-cause injury mortality in Guangdong province decreased significantly from 28.65 per 100 000 population during the control period to 23.24 per 100 000 population during COVID-19 pandemic period. Similar results were found in specific injury categories. Mortality of self-harm increased by 139.26% in the 10–14 year group during the COVID-19 period as compared with the control period. Although mortality changes in some groups were not statistically significant, some increases were noteworthy during the COVID-19 period (ie, self-harm, transport injury and falls) in the 70–79 year group. The corresponding increase in mortality rate was 16.83%, 3.32% and 4.92%, respectively.

**Conclusion** The mortality of all-cause injury, transport injury and drowning during the COVID-19 pandemic was consistently decreased. However, the increase in mortality associated with falls, fire/heat/hot substance injury and self-harm in specific age populations warrant the targeted control and prevention measures for the population at risk.

## INTRODUCTION

Recent studies have shown that the COVID-19 pandemic confers a profound effect on all aspects of the society that has been extended to the mental health. Significant decreases in the rate of acute coronary syndrome-related hospitalisation and outpatient visits have been reported in Italy during the early COVID-19 outbreak.<sup>1,2</sup> The projected increases in suicide have also been linked to the COVID-19 outbreak in Canada.<sup>3</sup> The vicarious traumatization scores of the

## Strengths and limitations of this study

- This is the first study comparing the injury mortality between the COVID-19 period and the control period.
- The completeness of death surveillance in Guangdong province was estimated using an empirical method to minimise under-reporting.
- The causative effect of the COVID-19 epidemic on injury mortality could not be confirmed due to the limitation of the observational study design.
- There was a lack of injury incidence, which should be regarded as another limitation of measuring the injury-associated burden.

general public have recently been shown to be significantly higher than those of the frontline nurses.<sup>4</sup> Different levels of psychological impacts (including stress, anxiety and depression) might have accounted for the increase in the suicidal events. Multidisciplinary research priorities for the COVID-19 pandemic have called for an urgent action for mental health science.<sup>5</sup>

During the COVID-19 pandemic, strict quarantine measures have been introduced to curb the transmission of SARS-CoV-2 in mainland China, including the people who have not contracted COVID-19.<sup>6</sup> Guangdong is a major province that has suffered from one of the major massive epidemics of COVID-19 in mainland China. The government had enforced stringent quarantine and lockdown measures with an unprecedented effort to contain the COVID-19 outbreak. Except for those who were responsible for providing the daily necessities and emergency services, the workforce has ceased working since the Chinese Lunar Calendar New Year (24 January 2020) and were requested to return to work after 10 February 2020. COVID-19 has also markedly dampened the global social orders and economy.<sup>7</sup>

Guangdong province has 108 million permanent residents that account for 8.03%

of the population in mainland China. Twenty-one cities with 122 counties are located in Guangdong province. Compared with other provinces, Guangdong has achieved the highest gross domestic product and become the most developed province with the largest population in southern China. Currently, little is known about the mortality changes of injury (including suicide) in different age and sex strata during the COVID-19 period in southern China.

We hypothesised that there would be both physical and mental health issues caused by the lockdown and quarantine measures during the COVID-19 period. We sought to ascertain the injury mortality changes in Guangdong province. Our findings might help provide the evidence about the *status quo* of injury and mental health, as well as the guidance and actionable information for governments and public health authorities during the COVID-19 pandemic.

## METHODS AND MATERIAL

### Study design and data source

We conducted a population-based retrospective analysis to compare the mortality changes of injury in different categories (including transport injuries, poisonings, falls, fire/heat/hot substances, drowning, self-harm and interpersonal violence, which were stratified by sex and age) between the study and control period. The study period was defined as the duration between the date of

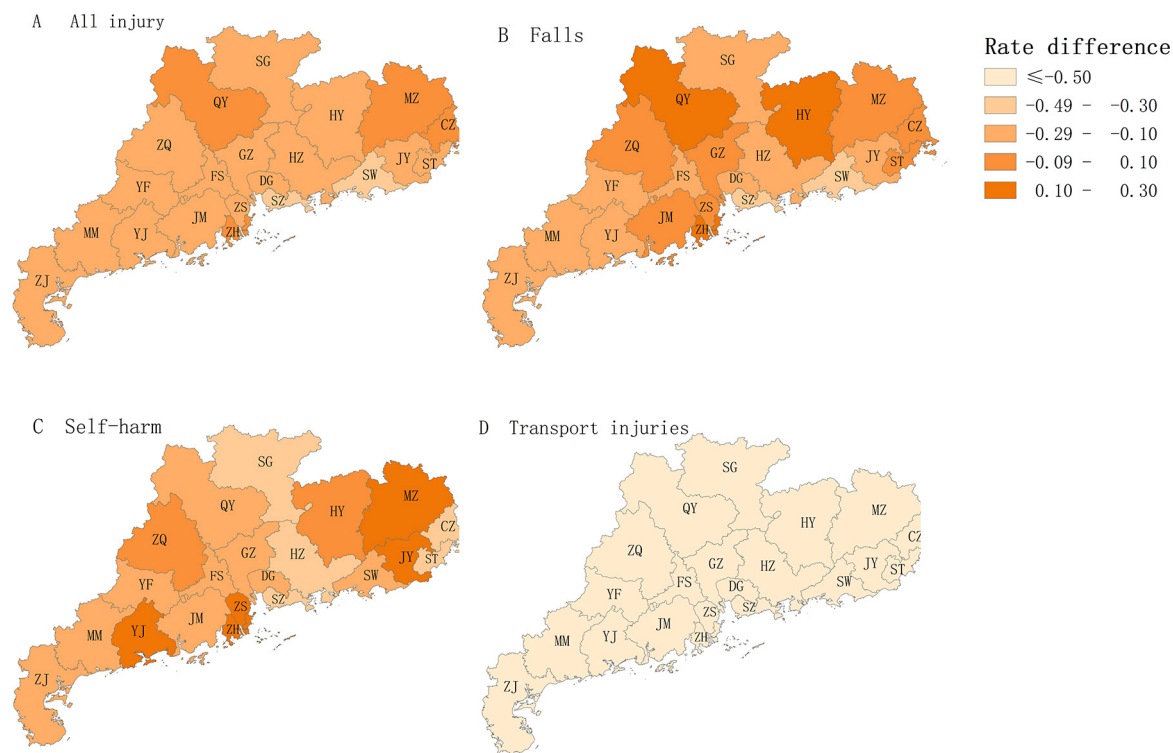
the identification of the first cases and the date when quarantine measures were implemented in Guangdong province (1 January 2020) and the data cut-off (30 June 2020). The control period was defined as a corresponding period during the previous year (from 1 January 2019 to 30 June 2019). Death registration is an all-cause of death surveillance that covers the whole population residing in Guangdong province. Mortality data were derived from the Chinese Center for Disease Control and Prevention (CDC) Cause of Death Reporting System.<sup>8</sup>

### Definition of major injury category

Injury deaths were identified according to the International Classification Of Diseases (ICD-10) codes as recommended by the US CDC,<sup>9,10</sup> based on the diagnostic codes of V01–Y89. Based on published studies and the ICD-10 codes of injury, we selected several categories of injury: transport injuries (V01–V04, V06, V09–V80, V87, V89 and V99), poisonings (X40–X49), falls (W00–W19), fire, heat and hot substances (X00–X09), drowning (W65–W74), self-harm (X60–X84 and Y87.0) and interpersonal violence (X85–Y09 and Y87.1).

### Statistical analyses

The registered population number in different age and sex strata in both 2019 and 2020 that corresponded to different cities in Guangdong province were obtained from the Population Basic Information System, which served as the denominators for mortality calculation. The



**Figure 1** All injury, transport injuries, falls and self-harm mortality changes between the COVID-19 pandemic period and control period in 21 cities in Guangdong province, China. CZ, Chaozhou; DG, Dongguan; FS, Foshan; GZ, Guangzhou; HY, Heyuan; HZ, Huizhou; JM, Jiangmen; JY, Jieyang; MM, Maoming; MZ, Meizhou; QY, Qingyuan; SG, Shaoguan; ST, Shantou; SW, Shanwei; SZ, Shenzhen; YF, Yunfu; YJ, Yangjiang; ZH, Zhuhai; ZJ, Zhanjiang; ZQ, Zhaoqing; ZS, Zhongshan.

**Table 1** Comparison of mortality for injury causes between the onset of the COVID-19 outbreak and the control period in Guangdong province

Injury subtypes	Study period (1/100 000)	Control period (1/100 000)	Changes (%)	P value
All cause of injury	23.24	28.65	-18.86	<0.0001
Transport injuries	5.06	7.11	-28.80	<0.0001
Poisonings	1.04	1.18	-11.71	0.028
Falls	8.45	9.31	-9.30	<0.0001
Fire, heat and hot substances	0.17	0.24	-28.41	0.012
Drowning	1.23	1.87	-34.51	<0.0001
Self-harm	3.04	3.73	-18.46	<0.0001
Interpersonal violence	0.16	0.29	-43.19	<0.0001

percentage changes were calculated with the following formula:

$$\frac{\text{Mortality in COVID-19 period} - \text{Mortality in control period in 2019}}{\text{Mortality in control period in 2019}} \times 100\%$$

The completeness of death surveillance in Guangdong province was estimated empirically.<sup>11</sup> Briefly, the following equation was applied to predict the completeness for both sexes:

$$\begin{aligned} \text{logit}(C^{\text{All}}) &= (\text{RegCDRsq} \times -0.0238) + (\text{RegCDR} \times 0.8419) \\ &+ (\%65 \times -19.6118) + (\ln(5q0) \times -1.5135) \\ &+ (\text{Year} \times -0.0251) + 44.3755 + \gamma \end{aligned}$$

where  $C^{\text{All}}$  was the completeness of the registration of all ages,  $\text{logit}(C^{\text{All}})$  equalled to  $\ln\left(\frac{C^{\text{All}}}{1-C^{\text{All}}}\right)$ ,  $\text{RegCDR}$  was the registered crude death rate (CDR),  $\text{RegCDRsq}$  was the square of  $\text{RegCDR}$ ,  $\%65$  was the fraction of the population aged 65 years or greater,  $\ln(5q0)$  was the natural log of the under-5 mortality rate,  $\text{Year}$  was calendar year and  $\gamma$  was a random effect. The predicted completeness was converted by using the inverse logit:  $\frac{e^{\text{logit}(C^{\text{All}})}}{e^{\text{logit}(C^{\text{All}})} + 1}$

Because of the overdispersion of injury deaths, we used negative binomial models to explore the associations of deaths within the COVID-19 period in different sex and age strata.<sup>12 13</sup> All statistical analyses were conducted using Stata statistical software V.12.1. Differences were considered statistically significant in the two-tailed tests if the p values were less than 0.05.

### Patient and public involvement

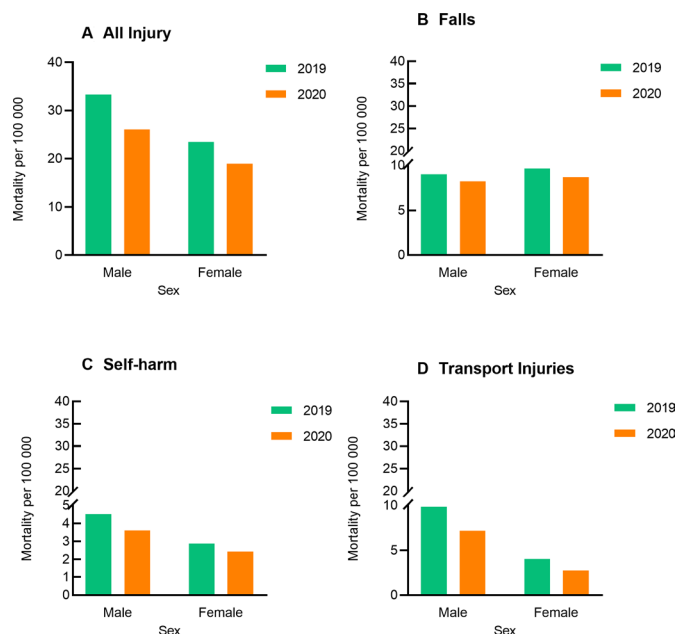
No patient involved.

## RESULTS

The completeness was 97.03% and 98.53% based on the empirical estimation, respectively. The all-cause injury mortality in Guangdong province decreased from 28.65 per 100 000 population in the control period to 23.24 per 100 000 people in the COVID-19 pandemic ( $p < 0.05$ ). Furthermore, the mortality of specific injury categories including transport injuries (5.06 per 100 000 population vs 7.11 per 100 000 population), poisonings (1.04 per 100 000 population vs 1.18 per 100 000 population), falls

(8.45 per 100 000 population vs 9.31 per 100 000 population), fire, heat and hot substances (0.17 per 100 000 population vs 0.24 per 100 000 population), drowning (1.23 per 100 000 population vs 1.87 per 100 000 population), self-harm (3.04 per 100 000 population vs 3.73 per 100 000 population) and interpersonal violence (0.16 per 100 000 population vs 0.29 per 100 000 population) decreased significantly during the COVID-19 pandemic as compared with the control period (all  $p < 0.05$ , [figure 1](#), [table 1](#)).

The mortality from all-cause and specific category injuries (including transport injuries, falls, fire/heat/hot substances, drowning, self-harm and interpersonal violence) decreased significantly in the total population and in both males and females, with exception of heat and hot substances in females ([figure 2](#), [table 2](#)). Stratification of the study population into different age strata revealed a significantly increased mortality. The self-harm mortality in the 10–14 year group significantly increased



**Figure 2** All injury, transport injuries, falls and self-harm in different sex groups between the COVID-19 pandemic period and control period in Guangdong province, China.

**Table 2** Mortality changes (%) in injury causes between the COVID-19 outbreak and control period in different age groups of males and females in Guangdong

Sex strata	Age group	Transport injuries	Poisonings	Falls	Fire, heat and hot substances	Drowning	Self-harm	Interpersonal violence	All-cause of injury
Male	0–14	-32.25*	-39.30	-13.19	-69.83*	-19.32	151.49* (10–14 years)	56.90	-22.50*
	15–59	-31.56*	-10.15	-16.89*	-48.01*	-32.84*	-24.25*	-55.36*	-25.99*
	60–69	-35.86*	3.30	-27.63*	-42.45	-45.88*	-19.98	-35.54	-29.49*
	70–79	7.44	-0.94	6.75	-40.91	-41.31*	21.41	87.11	2.71
	80+	-13.68	-6.54	5.45	32.16	-15.04	-43.68*	3.84	0.53
	Total	-27.06*	-9.16	-8.72*	-39.99*	-30.90*	-20.19*	-40.54*	-19.56*
Female	0–14	-36.34*	-35.24	-8.50	-6.46	-55.27*	127.00* (10–14 years)	-48.98	-37.04*
	15–59	-36.42*	-20.97	-10.48	-36.32	-41.98*	-19.51*	-47.01*	-26.13*
	60–69	-43.33*	-14.22	-21.81	51.38	-50.51*	-35.40*	-52.69	-35.63*
	70–79	-2.53	-22.83	3.49	49.58	-0.44	12.40	-28.77	2.51
	80+	-33.09*	101.69	-6.87*	31.10	-42.37*	0.85	0.85	-6.86*
	Total	-32.78*	-16.62	-9.93*	-1.21	-40.67*	-15.17*	-46.06*	-17.58*
General population	0–14	-34.07*	-36.68*	-11.18	-52.00	-31.89*	139.26* (10–14 years)	-16.00	-28.87*
	15–59	-32.71*	-13.13*	-15.56*	-44.10*	-35.25*	-22.67*	-51.68*	-25.99*
	60–69	-38.81*	-3.04	-27.01*	-31.62	-48.12*	-27.24*	-45.90	-32.22*
	70–79	3.32	-12.44	4.92	-22.48	-20.40	16.83	27.69	2.12
	80+	-21.92	29.26	-2.45	31.20	-33.03*	-22.78	2.05	-4.04
	Total	-28.80*	-11.71*	-9.30*	-28.41*	-34.51*	-18.46*	-43.19*	-18.86*

\*Statistical significance using negative binomial model for comparison of COVID-19 period and control period in 2019 ( $p < 0.05$ ).

in males, females and the general population. Although the increased mortality of self-harm, transport injury, falls and interpersonal violence in the 70–79 year group did not reach statistical significance, the increase in mortality in this age group was noteworthy. Moreover, there was an insignificant increase in mortality from fire, heat and hot substances in the 80+ year group in both sexes as well as from falls in the 80+ year group among males (figure 3, table 2).

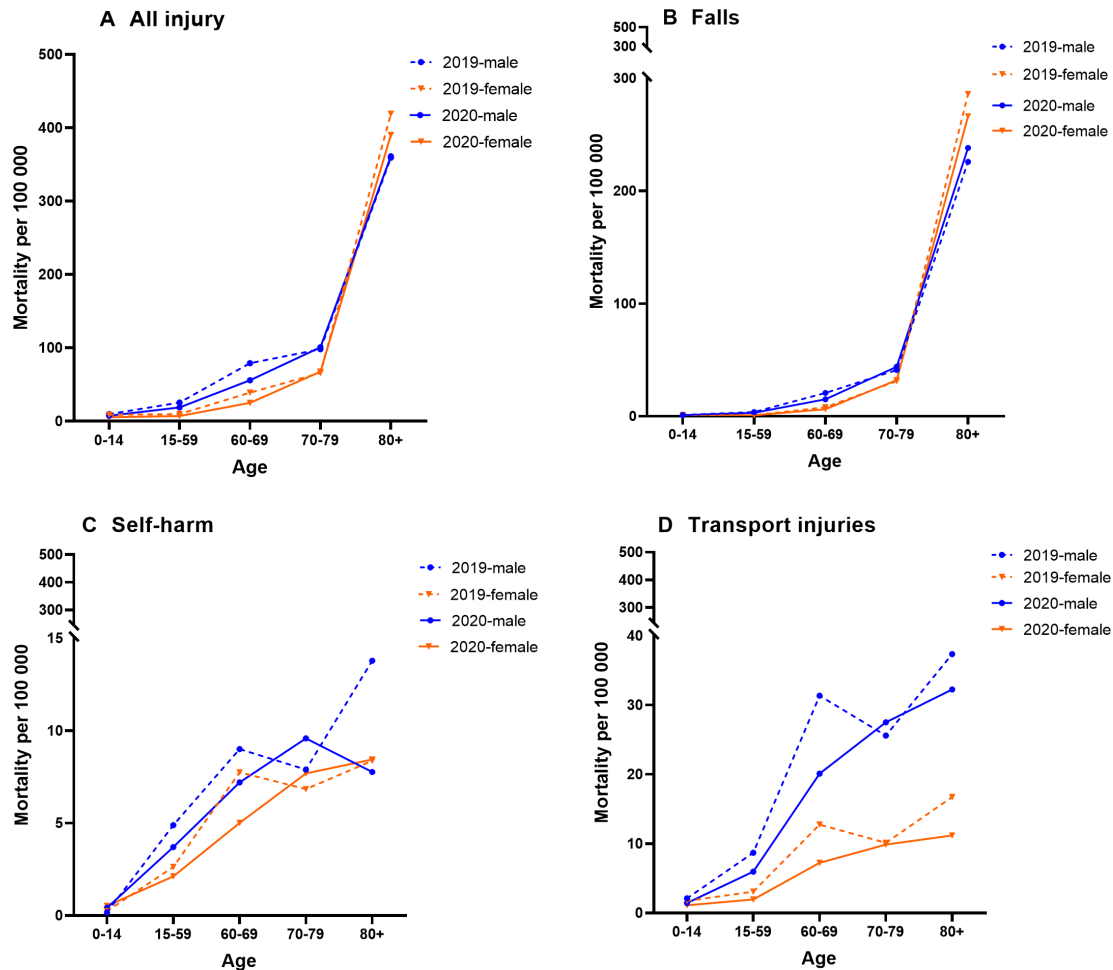
The number of deaths due to all-cause injuries and specific types of injuries in different age groups and cities are provided in the online supplementary material (online supplemental eTable 1–3).

## DISCUSSION

Our study revealed that the mortality from all-cause injury and specific categories of injury (including transport injuries, poisonings, falls, fire/heat/hot substances, drowning, self-harm and interpersonal violence) has decreased dramatically, which might have resulted from the COVID-19 pandemic. However, stratification of the study population into different city, age and sex strata has unravelled a significantly increased mortality in certain types of injury. Despite that the mortality changes in

some strata did not reach statistical significance, there has been a notably increased mortality during the COVID-19 period (ie, self-harm, transport injury, falls and interpersonal violence in the 70–79 year group). This has shed light on the priorities and longer term strategies for injury and mental health scientific research, control and prevention. To our knowledge, this is the first study that demonstrated the injury mortality at different age and sex strata at the provincial level in mainland China. Our findings have added new insights by providing comparisons between the COVID-19 pandemic period and the control period in 2019.

Because our study was conducted during the COVID-19 pandemic when stringent lockdown and quarantine measures were enforced in mainland China, the most prominent impact of COVID-19 on injury could not be fully captured. During the COVID-19 outbreak, most people avoided outdoor activities to minimise the use of healthcare services and avoid the SARS-CoV-2 infection. Consequently, there has been a notable decrease in the mortality from transport injury and drowning at all age strata. Similar results have been documented in the UK<sup>14</sup> and India.<sup>15</sup> Degenerative spine and traumatic brain injuries also decreased significantly during the COVID-19



**Figure 3** All injury, transport injuries, falls and self-harm mortality changes in different age and sex groups between the COVID-19 pandemic period and control period in Guangdong province, China.

pandemic in UK.<sup>14</sup> The lockdown has grossly decreased the disability-adjusted life years caused by road traffic injury.<sup>15</sup>

It remains unclear why the mortality of fire, heat and hot substances in the general population decreased during the COVID-19 period based on the existing data and literature reports. In line with our study, some researchers have demonstrated a higher mortality in the elderly.<sup>16 17</sup> In the UK, scalds accounted for 60% of the deaths of fire, heat and hot substances in the >75 year group.<sup>18</sup> By contrast to the findings from the previous study, fire or smoke inhalation caused by fire are the main causes of the increased mortality among the elderly during the COVID-19 period in our study. People who died from fire, heat and hot substances were reported from the rural areas, where the elderly living alone were more likely to use biomass fuel (ie, wood, coal, animal dung and crop residues) for cooking and heating. A comprehensive strategy that integrates public education, distribution of firefighting equipment, adequate supervision for the vulnerable adults while heating and cooking and the use of ageing electric appliance in the elderly would be indispensable to improve public health.

The causes of death from interpersonal violence have been multifactorial. Theoretically, unemployment and fear of acquiring COVID-19 would have predisposed to an increased incidence of household interpersonal violence that has been non-fatal. By contrast, both the incidence and mortality of social interpersonal violence would sharply decrease because of the stringent lockdown and quarantine measures that might have been fatal. The decrease in the mortality associated with social interpersonal violence might have largely been offset by the non-fatal incidence of household interpersonal violence.

The death rate of falls has been declining despite a notable increase in the elderly, which is probably due to the increased life expectancy in the past two decades. A greater proportion of the elderly living with chronic diseases were at risk of falls.<sup>19</sup> This tended to be aggravated during the COVID-19 period because the elderly remain exposed to trauma due to domestic falls with a reduced number of healthcare services.<sup>20</sup> In this scenario, the elderly suffered from a increased risk of having disability or death due to the delayed care and treatment for fall-related injuries.<sup>21 22</sup> Given the relatively high burden of falls among the elderly, a systematic implementation

to reduce the incidence of injuries from falls would be urgently needed. These measures include a sufficient medical and occupational therapy,<sup>23</sup> professional environment hazard assessment and modification,<sup>24</sup> vitamin D and calcium supplementation, hip protectors and reduction of many of the predisposing risk factors.<sup>25</sup>

Self-harm is becoming a more pressing concern as the pandemic is spreading rapidly and has the longer term effects on the general population, the economy and the vulnerable population. The infectious disease epidemics seemed to serve as a catalyst to trigger the suicidal attempt of people with mental health disorders.<sup>26 27</sup> Our results revealed an increased death rate for self-harm in the 10–14 year and 70–79 year group in both sexes. The likely adverse effects of the pandemic on children's mental health might be exacerbated by fear of being infected by SARS-CoV-2, self-isolation and physical distancing because of school closure.<sup>28</sup> These contributed to an increase in the prevalence of post-traumatic stress disorder symptoms, depression, anxiety and stress.<sup>29</sup> In conjunction with a higher risk of being exposed to the family conflicts, the household physical violence, academic stress and economic damage that were caused by the COVID-19 crisis might have collectively led to an increased rate of suicide among children.<sup>30</sup> A loss of employment, financial stressors and alcohol consumption, which have also been the well-recognised risk factors causing family conflict,<sup>31</sup> might have aggravated during the lockdown. Despite of the mental health disorders and the family conflict, the elderly might be increasingly concerned because of the extraordinarily high case fatality rate.<sup>32</sup> This might have also contributed to the increased risk of self-harm in the elderly. Selective and universal interventions are required for the targeted individuals at risk of suicide, including sharing the evidence-based interventions online, increasing volunteer workforce for crisis hot lines and providing financial safety nets for unemployment support.<sup>33</sup> Public health responses must ensure that those facing interpersonal violence are supported and that safe drinking messages are communicated, particularly for the bereaved individuals. Accessible health education and promotion for COVID-19 is recommended, because a study has reported that people who were proactively engaged in hand hygiene could have a decreased likelihood that the workforce experience psychiatric symptoms.<sup>29 34</sup>

Some limitations should be addressed. There was a lack of reliable injury incidence data. Therefore, the comparability of mortality data and incidence data due to the death registration completeness and coverage should be interpreted with caution. Although we have used an empirical method to minimise the underestimation in the death surveillance, the magnitude of completeness of the mortality data varied considerably for children and adult deaths based on the Global Burden of Disease (GBD) 2010 study's finding.<sup>35</sup> The completeness of data in children was usually lower than that in adults in Latin America and Asia. Second, caution should also be

exercised regarding the causative effect of the COVID-19 epidemic on injury mortality because of the limitation of the observational study design.

Despite these limitations, our findings remained robust. The death registration is an all-cause death surveillance that covered all the population residing in Guangdong province. Data from the registration system in the recent years have been aligning well with the vital registration data that achieved a large increase in the coverage over the past decade.<sup>36</sup>

In conclusion, the COVID-19 pandemic was associated with a decreased mortality of all injury, transport injury and drowning. However, the increase in the mortality of falls, fire, heat and hot substances injury, self-harm in specific age populations during the COVID-19 period still warrant the targeted and universal interventions for the mass public.

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