



Long-term Trends in Child and Youth Injury Mortality in Taiwan, 1989-2007

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Background: Injuries are the leading causes of death and contribute greatly to morbidity in children. Our study examined injuries' age and gender-specific variations over time among children 0-19, from 1989 to 2007. **Materials and Methods:** Numbers of deaths caused by injury are drawn from Taiwan's official Vital Statistics System. Mortality was age-adjusted to the US 2000 standard population. Temporal trends were analyzed by linear regression. **Results:** Both genders' annual mortality rates and proportional mortality ratios of unintentional injuries declined significantly during 1989-2007. Conversely, an increasing trend of intentional deaths occurred. In general, during 1992-2007, increasing the rates of suicide deaths in ages 10-19 and of homicide deaths in ages 0-9 occurred. Boys had more suicide deaths than did girls. **Conclusions:** Unlike unintentional injuries, intentional injuries increased over the 1989-2007 period. Deaths in the subgroups of ages 0-19 and categorized by genders were caused by varying injuries.

Key words: Children, gender, injury, mortality, trends

INTRODUCTION

Injuries are the leading causes of death in children and youth. There were 421 deaths of children caused by injury in Taiwan in 2013¹ and throughout the world in 2004, there were about 950,000 deaths in children aged <18.² Injury is closely connected to children's health³, and therefore, injury prevention is a crucial component of a nation's public health agenda.

In Taiwan, the majority of deaths caused by injuries in children and adolescents were due to road traffic collisions, drowning, burns (fire and scalds), falls or poisoning.⁴ Public health-related efforts raised the amount of national attention which was placed on injury prevention, although the mortality rates of total injuries from ages 0 to 19 dropped from 35.3 to 10.8/100,000 persons (decline proportion: 69%) in 1986-2006,⁵ but they were still high. Regarding mortality trends of injuries in Taiwan, the studies were less focused on

youth and children⁵ but on all ages. Or they did not specify the risk ratios of genders of each injury.⁶ In addition, genders and ages are crucial factors for the variation of mortality trends and injury causes of death in youth and children. Therefore, it is necessary to analyze the details of temporal trends and causes of death in injuries stratified by genders and subgroups of ages in order to identify the particular injury's causes, as well as to evaluate the further effectiveness of injury prevention. This study aimed to examine the temporal trends of mortality rates caused by injuries, as well as the major causes of death, among children aged 0-19, and stratified by ages and genders.

MATERIALS AND METHODS

Annual death data were obtained from Taiwan's official Vital Statistics System from 1989 to 2007.⁷ Since 2001, the new Classification of Diseases 10th version (ICD-10) began to be implemented with ICD-9 at the same time. To avoid the outcome biased by the change of ICD versions, we only included ICD-9 data from 1989 to 2007. The data after 2007 in ICD-10 coding were excluded. Registration of deaths is required by law in Taiwan. Officers in each administrative division area must report deaths to the Health Department of the Executive Yuan. It includes demographic characteristics (e.g., age, gender, residency, marriage, job title, etc.), site

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of death, date of death, diagnostician, and causes of death (classified by ICD-9-E codes).

Injuries were classified by intent (3 categories) and mechanism (23 categories). Three intents included unintentional injuries (E800-E949), intentional injuries (E950-E978 and E990-E999), and undetermined injuries (E980-E989). The ICD-9-E codes of 23 categories of mechanism were E800-E807, E810-819, E820-E825, E826-E829, E830-E838, E840-E845, E846-E848, E850-E858, E860-E869, E870-E876, E878-E879, E880-E888, E890-E899, E900-E909, E910-E915, E916-E928, E929, E930-E949, E950-E959, E960-E969, E970-E978, E980-E989, and E990-E999. Since the major causes of death in infants (<1-year) were congenital diseases, they were classified into a separate stand-alone category when causes of death by injury were analyzed. Ages 0-19 were placed into 5 age-based subgroups: <1, 1-4, 5-9, 10-14, and 15-19. These corresponded to the grouping by Taiwan's official Vital Statistics Bureau.

The annual mid-population for calculating the injury mortality rates was obtained from the Department of Statistics, Ministry of the Interior.⁸ The registration of births, deaths, and immigrations, as well as the constant census-taking, were carried out according to the provisions of Taiwanese law. Taiwan National Households Database was drawn for the population-based data in this study. Age-adjusted mortality rates are calculated using the direct method with reference to US 2000 standard population for international comparison. Linear regression was used to calculate the temporal trends of injury mortalities. The gender difference of injury mortalities was examined by calculating the relative risk ratio. Proportional mortality ratio (PMR) is the number of observed deaths from a specified cause divided by the number of all deaths in a defined

population. PMR for total injuries in ages 0-19 was calculated to find the major contributors to death.

RESULTS

Mortality trends of intents

Injuries were the major causes of death in youth, in 2007, injuries accounted for 31% of the total causes of death in ages 0-19 [Supplemental Figure S1], whereas they accounted for only 5% in all ages.¹ Thirty-five thousand seven hundred and twenty-four children aged 0-19 died of injuries in Taiwan from 1989 to 2007 (an average of 1881 deaths/year). Unintentional and intentional injuries accounted for 92% and 6% of total injury deaths, respectively. There was a significant decrease in unintentional injuries from 1989 to 2007, declining from 56.1 to 14.5/100,000 ($P < 0.001$) in boys and from 25.3 to 6.4/100,000 ($P < 0.001$) in girls, but with no significant decrease in intentional injuries [Supplemental Table S1].

Mortality trends by genders and injuries

Between 1989 and 2007, age-adjusted mortality rates related to injuries declined significantly in 5-year age groups of 0-19 years, and those for boys aged 0-19 years were 2.1 times higher than girls [Table 1, Figure 1, and Supplemental Figure S1]. Boys at higher risks of dying from injuries than girls were especially worse in 15-19 years [Table 1]. The injury-related death rate of 15-19 years was the highest among 0-19 years, those for 0-4 and 15-19 years were generally higher than 5-9 and 10-14 years. The high injury-related mortality rates in 0-4 years were mainly attributed to the high injury death of infants (<1-year) [Figure 1].

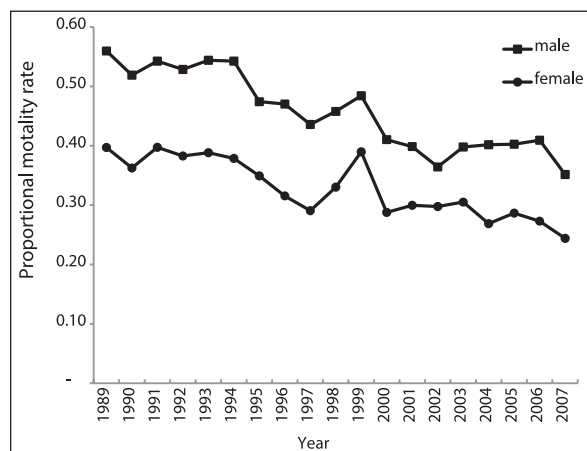


Figure S1: Proportional mortality ratios of total injuries by genders in ages 0-19 in Taiwan, 1989-2007. Proportional mortality ratios declined from 56% to 35% in boys (decline proportion = 37.5%, $P < 0.01$) and from 40% to 24% in girls (decline proportion = 16%, $P < 0.01$)

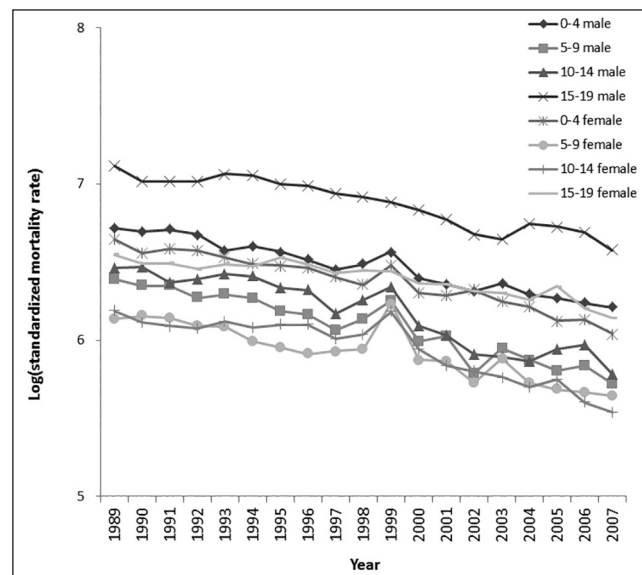


Figure 1: Log-transformed age-adjusted mortality rates for total injuries by ages and genders in Taiwan, 1989-2007. The peaks which appeared in 1999 were caused by the large scale earthquake of September 21, 1999 in Taiwan

Leading causes of death due to injuries for ages 0-19 from 1989 to 2007 were motor vehicle traffic (MVT, E810-819), suffocation/drowning/foreign bodies (SDF, E910-915), falls (E880-888), fire/flames (E890-899), suicide (E950-959), and homicide (E960-969) [Figure 2]. Except for suicide and homicide, the other injury mortalities declined significantly ($P < 0.001$), especially MVT and SDF, which had the most significant decline rates with 0.76 and 0.53/100,000/year, respectively.

The leading causes of injury-related deaths and temporal trends were similar in both genders among 0-4 years

Table S1: The death number and age-adjusted mortality rates per 100,000 for unintentional and intentional injuries by genders in ages 0-19 in Taiwan, 1989-2007

Year	Unintentional injuries				Intentional injuries			
	Boys		Girls		Boys		Girls	
	<i>n</i>	Rate ^Δ	<i>n</i>	Rate ^Δ	<i>n</i>	Rate ^Δ	<i>n</i>	Rate ^Δ
1989	2,093	56.1	877	25.3	117	3.1	56	1.6
1990	1,803	48.6	756	21.8	89	2.4	51	1.4
1991	1,755	47.7	778	22.6	70	1.9	30	0.8
1992	1,715	46.3	730	21.4	70	1.9	25	0.7
1993	1,809	48.0	734	21.2	59	1.6	29	0.8
1994	1,761	46.4	676	19.5	87	2.3	28	0.8
1995	1,568	40.8	682	19.5	62	1.6	45	1.2
1996	1,482	38.6	642	18.5	64	1.6	30	0.8
1997	1,256	32.6	553	16.1	83	2.1	42	1.2
1998	1,256	33.3	534	15.7	85	2.2	47	1.3
1999	1,320	36.1	680	20.9	56	1.5	35	1.0
2000	975	26.7	429	13.2	48	1.3	46	1.4
2001	826	23.4	389	12.3	64	1.8	41	1.2
2002	613	18.0	348	11.5	67	1.9	37	1.2
2003	614	18.8	319	10.9	49	1.5	43	1.4
2004	615	19.5	269	9.6	66	2.0	36	1.2
2005	592	19.2	264	9.5	64	2.0	50	1.8
2006	553	18.1	208	7.7	67	2.1	37	1.4
2007	441	14.5	170	6.4	45	1.4	38	1.3
Average	1,213		528		69		39	
Proportion	0.65		0.28		0.04		0.02	
Decline proportion	0.74		0.75		0.55		0.19	
Annual change rate	-2.3		-0.98		-0.03		0.02	
Lower 95% CI [§]	-2.57		-1.12		-0.001		-0.002	
Upper 95% CI [§]	-2.03		-0.84		-0.07		0.05	
<i>P</i> for trend	**		**		0.06		0.07	

[§]The upper and lower levels of 95% confidence interval of annual change rate in the linear regression; * $P < 0.05$, ** $P < 0.001$; ^ΔAge-adjusted mortality rates (100,000) to the US 2000 standard population

[Supplemental Figures S2 and S3]. However, the rankings of causes of injury-related deaths changed within the genders as children get older [Table 1 and Supplemental Figures S4-S6]. The mortality rates of 0-4 years dropped from 48.5 to 13.7/100,000 (decline proportion: 72%, $P < 0.001$) from 1989 to 2007.

Death rate of SDF fell from 67.5 to 18.7/100,000 (decline proportion: 72%, $P < 0.001$) among infants <1-year between 1989 and 2007, although it was much higher than that of any other injury and remained the leading cause of injury-related deaths (36.4/100,000/year on average) [Table 1, Supplemental Figure S2]. SDF and MVT were the two major causes of injury death in 1-4 years as the same as 5-14 years. Except for MVT and SDF, annual mortality rates of the other injuries in 1989-2007 generally fluctuated under 2.2 and 1.9/100,000/year in the 5-9 and 10-14 years, respectively [Supplemental Figures S4 and S5]. MVT became the major cause of injury-related death as a youth growing older. In ages 15-19, the average mortality rate of MVT (boys: 54.1/100,000/year, girls: 17.1/100,000/year) was the highest compared to those of the other subgroups in both genders [Table 1].

The higher relative risk ratios meant that boys had the higher mortalities of specific injury than girls. The mortality rates were similar between boys and girls for subjects age <1-year, but the mortalities in boys will be larger than in girls for subjects getting older ages. For most injuries (except homicide in ages 5-9, relative risk

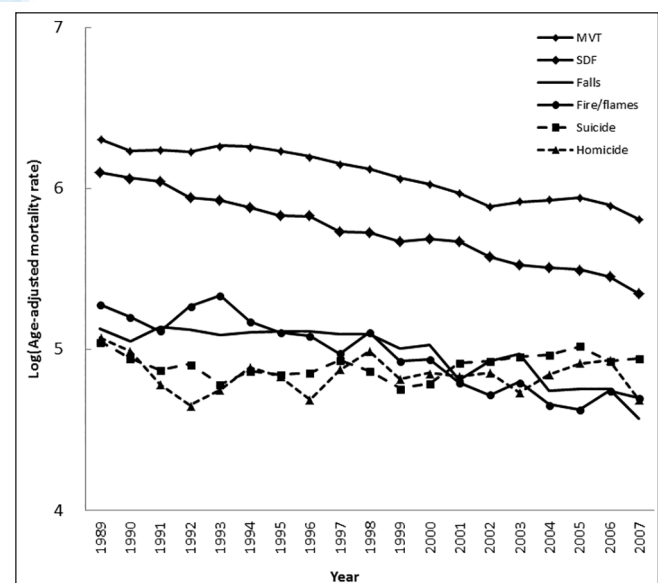


Figure 2: Log-transformed age-adjusted mortality rates of major injuries in ages 0-19 in Taiwan, 1989-2007. Motor vehicle traffic stands for motor vehicle traffic, which E codes are E810-819; SDF stands for suffocation/drowning/foreign bodies, which E codes are E910-915; falls: E880-888; fire/flames: E890-899; suicide: E950-959; homicide: E960-969

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Table 1: The average mortality rates per 100,000/year and relative risk ratio of top seven leading injury causes of death by age and gender in 0-19 age groups, Taiwan, 1989-2007

Ages		<1-year old			1-4 years old			5-9 years old		
Rank	Gender	Injury causes of death	Mortality rate (100,000)	Ratio ^A	Injury causes of death	Mortality rate (100,000)	Ratio ^A	Injury causes of death	Mortality rate (100,000)	Ratio ^A
1	Male	SDF	37.8	1.1 (1.0-1.2)	SDF	9.6	1.8 (1.6-1.9)*	SDF	5.1	2.6 (2.3-3.0)*
	Female	SDF	34.9	1.1 (1.0-1.2)	MVT	7.3	1.1 (1.0-1.2)	MVT	3.8	1.2 (1.1-1.3)*
2	Male	Other incidents	5.9	1.1 (0.9-1.4)	MVT	8.2	1.1 (1.0-1.2)	MVT	4.4	1.2 (1.1-1.3)*
	Female	Other incidents	5.4	1.1 (0.9-1.4)	SDF	5.5	1.8 (1.6-1.9)*	SDF	2	2.6 (2.3-3.0)*
3	Male	MVT	5.4	1.1 (0.9-1.4)	Other incidents	2.7	1.1 (1.0-1.4)	Other incidents	1.4	2.1 (1.6-2.6)*
	Female	MVT	4.8	1.1 (0.9-1.4)	Other incidents	2.3	1.1 (1.0-1.4)	Fire/flammes	1	1.1 (0.9-1.3)
4	Male	Falls	2.6	1.2 (0.9-1.8)	Fire/flammes	2.2	1.3 (1.1-1.6)*	Fire/flammes	1	1.1 (0.9-1.3)
	Female	Falls	2.1	1.2 (0.9-1.8)	Fire/flammes	1.7	1.3 (1.1-1.6)*	Other incidents	0.7	2.1 (1.6-2.6)*
5	Male	Undetermined intent	1.3	1.5 (0.9-2.6)	Falls	2.1	1.5 (1.2-1.8)*	Falls	0.7	1.9 (1.4-2.7)*
	Female	Fire/flammes	1.6	0.8 (0.5-1.3)	Falls	1.4	1.5 (1.2-1.8)*	Nature/environment	0.6	0.8 (0.6-1.1)
6	Male	Fire/flammes	1.3	0.8 (0.5-1.3)	Homicide	0.7	0.9 (0.7-1.3)	Nature/environment	0.5	0.8 (0.6-1.1)
	Female	Homicide	0.9	1.0 (0.6-1.8)	Homicide	0.7	0.9 (0.7-1.3)	Homicide	0.6	0.6 (0.4-0.8)*
7	Male	Homicide	0.9	1.0 (0.6-1.8)	Nature/environment	0.6	0.9 (0.7-1.3)	Homicide	0.4	0.6 (0.4-0.8)*
	Female	Undetermined intent	0.9	1.5 (0.9-2.6)	Nature/environment	0.7	0.9 (0.7-1.3)	Falls	0.3	1.9 (1.4-2.7)*
All injuries	Male		56.1	1.1 (0.7-1.6)		27.4	1.3 (0.7-2.3)		14.1	1.5 (0.7-3.4)
	Female		51.3			20.7			9.4	
Ages		10-14 year old			15-19 years old			0-19 years old		
Rank	Gender	Injury causes of death	Mortality rate (100,000)	Ratio ^A	Injury causes of death	Mortality rate (100,000)	Ratio ^A	Injury causes of death	Mortality rate (100,000)	Ratio ^A
1	Male	MVT	7.6	1.5 (1.4-1.7)*	MVT	54.1	3.2 (3.0-3.3)*	MVT	19.4	2.3 (2.2-2.4)*
	Female	MVT	5	1.5 (1.4-1.7)*	MVT	17.1	3.2 (3.0-3.3)*	MVT	8.4	2.3 (2.2-2.4)*
2	Male	SDF	5.7	3.1 (2.8-3.6)*	SDF	8.5	6.4 (5.5-7.3)*	SDF	8.3	2.3 (2.1-2.4)*
	Female	SDF	1.8	3.1 (2.8-3.6)*	Suicide	2.1	1.7 (1.5-1.9)*	SDF	3.7	2.3 (2.1-2.4)*
3	Male	Other incidents	1.3	2.1 (1.6-2.6)*	Other incidents	6.9	4.7 (4.1-5.3)*	Other incidents	3.3	2.4 (2.2-2.6)*
	Female	Fire/flammes	0.7	1.1 (0.9-1.4)	Other incidents	1.5	4.7 (4.1-5.3)*	Other incidents	1.4	2.4 (2.2-2.6)*
4	Male	Fire/flammes	0.8	1.1 (0.9-1.4)	Suicide	3.6	1.7 (1.5-1.9)*	Falls	1.3	1.9 (1.7-2.1)*
	Female	Other incidents	0.6	2.1 (1.6-2.6)*	SDF	1.3	6.4 (5.5-7.3)*	Fire/flammes	1	1.2 (1.1-1.3)*
5	Male	Falls	0.5	2.2 (1.5-3.3)*	Homicide	2.1	3.6 (2.9-4.4)*	Fire/flammes	1.2	1.2 (1.1-1.3)*
	Female	Nature/environment	0.4	0.9 (0.6-1.2)	Falls	0.8	2.5 (2.1-3.1)*	Falls	0.7	1.9 (1.7-2.1)*
6	Male	Suicide	0.4	1.1 (0.7-1.5)	Falls	1.9	2.5 (2.1-3.1)*	Suicide	1.1	1.6 (1.4-1.8)*
	Female	Suicide	0.4	1.1 (0.7-1.5)	Fire/flammes	0.7	1.3 (1.0-1.6)	Suicide	0.7	1.6 (1.4-1.8)*
7	Male	Nature/environment	0.3	0.9 (0.6-1.2)	Undetermined intent	1.2	2.0 (1.6-2.6)*	Homicide	0.9	1.7 (1.5-2.0)*
	Female	Poison	0.4	0.7 (0.5-1.0)	Homicide	0.6	3.6 (2.9-4.4)*	Homicide	0.5	1.7 (1.5-2.0)*
All injuries	Male		18	1.8 (0.8-3.8)		81.7	3.1 (2.0-4.8)*		37.5	2.1 (1.2-3.7)*
	Female		10.1			26.2			17.9	

* $P < 0.05$, ^AFemale mortality rates are divided into male mortality rates; The intentional injuries are marked in gray blocks; MVT = Motor vehicle traffic, which E codes are E810-819; falls: E880-888; fire/flammes: E890-899; nature/environment: E900-E909; SDF = Suffocation/drowning/foreign bodies; which E codes are E910-915; other incidents: E916-E928; suicide: E950-959; homicide: E960-969; undetermined intent stands for Injury undetermined whether accidentally or purposely inflicted, which E codes are E980-989

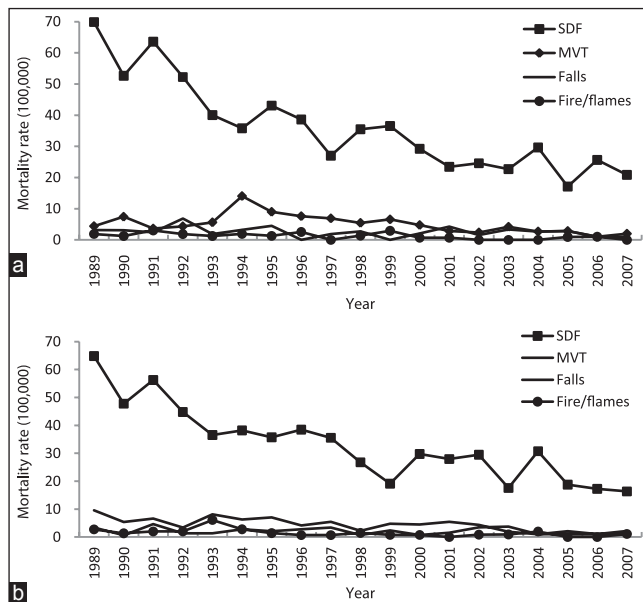


Figure S2: Mortality rates of leading intentional injuries of age <1-year. (a) Boys (b) Girls. Suffocation/drowning/foreign bodies were the leading injury causes of death in age <1-year for both genders in 1989-2007. There was no gender difference of mortality rates in this age group

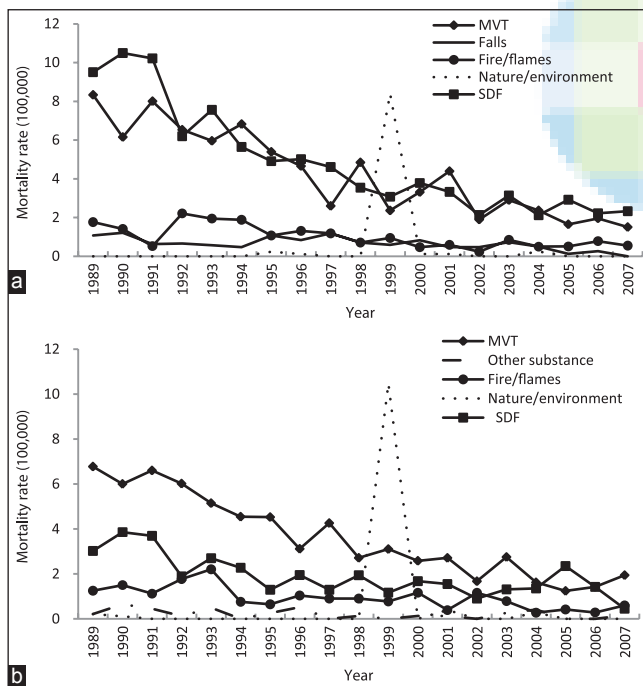


Figure S4: Mortality rates of leading intentional injuries of ages 5-9. (a) Boys (b) Girls

ratio: 0.6 [0.4-0.8]), boys were at a higher risk of dying from the injuries than girls, and the highest relative risk ratio appeared in SDF in ages 15-19 (6.4, 95% confidence interval = 5.5-7.3) [Table 1].

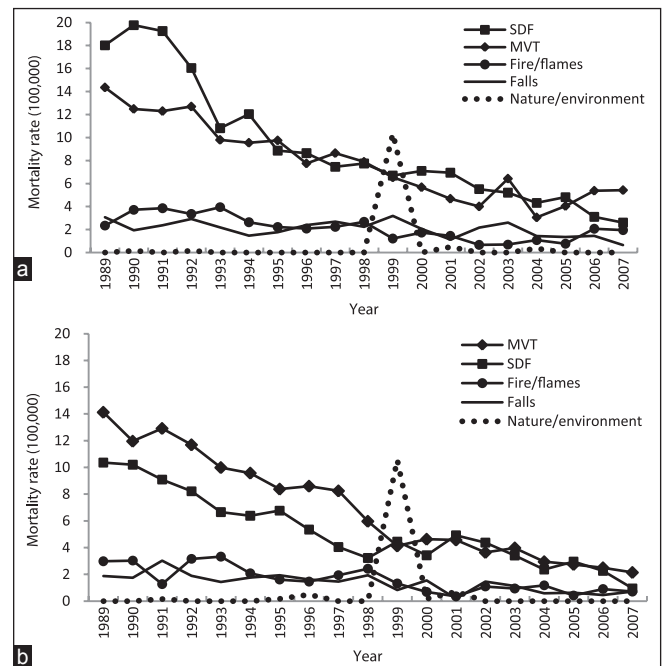


Figure S3: Mortality rates of leading intentional injuries of ages 1-4. (a) Boys (b) Girls. The temporal trends and mortality rates of falls and fire/flames were similar in both genders. However, boys had a higher risk of dying from motor vehicle traffic and suffocation/drowning/foreign bodies than did girls

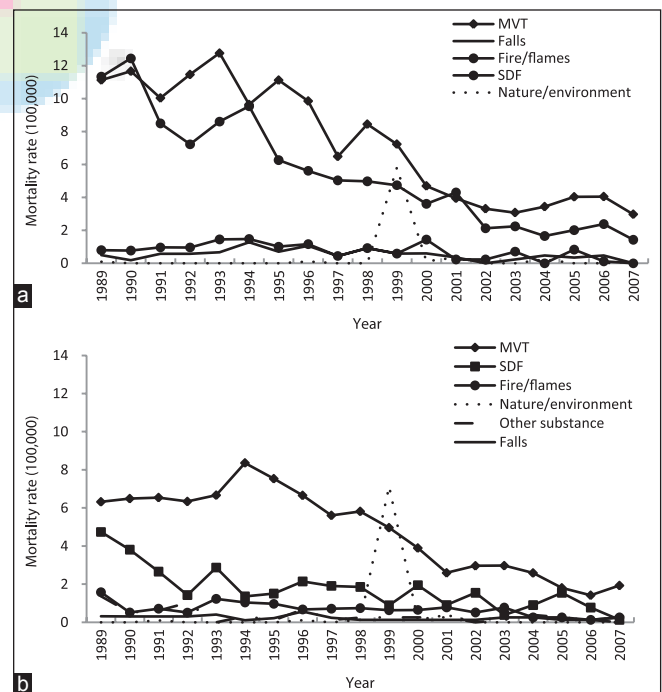


Figure S5: Mortality rates of leading intentional injuries of ages 10-14. (a) Boys (b) Girls. The temporal patterns of mortality rates in both genders are similar with ages 5-8. For boys, motor vehicle traffic and suffocation/drowning/foreign bodies were two major causes of death, but for girls only the former was the major one

Intentional injuries

Suicide and homicide were the two major intentional causes of death to children and youth. In 1987, the Taiwanese government declared an end to martial law, which restricted the freedom of assembly and association, and on political rights. Both of the society and economy became to develop in the years following 1987. In general, the trends in suicide and homicide mortalities decreased before 1992 and grew up after 1992 [Figures 3 and 4]. When we omitted the deaths in 1989-1991 and reanalyzed the trends, the increasing trend of suicide in girls aged 15-19 became significant [Figure 3]. On the other hand, the trend of homicide in boys aged <1-year became insignificant. Suicide mortalities were higher in 0-4 and 15-19 years, of which boys were at a higher risk of dying from suicide than were girls. Suicide mortality of ages 15-19 showed an increase in recent years, in that girls had a significant increasing trend ($P = 0.01$). Unlike the declining trends of the other top ranked injuries, the trends toward suicide either increased or held the line in different subgroups [Figure 3]. Homicide mortalities in older adolescents aged 10-19 were decreasing, whereas they increased in the children aged ≤ 9 . A significant increase was observed in girls

aged 1-9 years ($P < 0.001$), with a decrease in boys aged 15-19 ($P = 0.03$) [Figure 4].

DISCUSSION

This study examined the national database to provide powerful evidence of the national trends of injury mortalities, with nearly 36,000 (35,724) injuries from over 129 million youth and children aged 0-19 (129,257,983). Strengths of this study included its focus on youth and children aged 0-19 that can be stratified by genders, ages, and causes through the use of its long-term data. Data on causes of death are accurate because all deaths must be reported to the local authorities by law.⁹

The rise of intentional injuries

In child and youth, suicide and homicide are the two major intentional causes of death. Furthermore, they contributed to the rise of mortalities of intentional injuries.

Suicide is the third leading cause of death among young people in the US and represents a significant public health problem worldwide.¹⁰ Suicide mortality was higher for boys than for girls¹¹ and more severe in ages 15-19; it increased

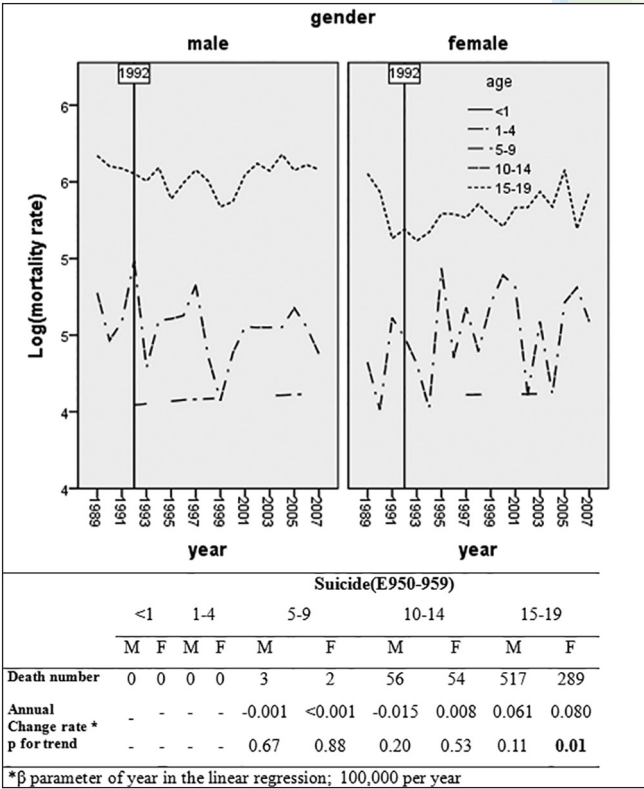


Figure 3: Log-transformed crude mortality rates of suicide in five subgroups of ages 0-19 in Taiwan, 1992-2007. The table at the bottom was calculated based on the data in 1992-2007 after the vertical line 1992 in this figure. Values in bold represented that the specific mortality rates were significant for linear trend test ($P < 0.05$)

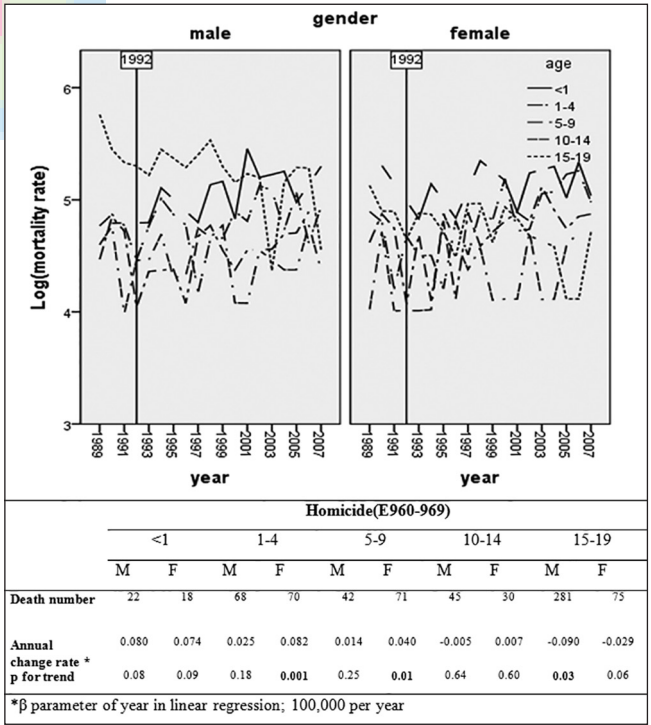


Figure 4: Log-transformed crude mortality rates of homicide in five subgroups of ages 0-19 in Taiwan, 1992-2007. The table at the bottom was calculated based on the data in 1992-2007 after the vertical line 1992 in this figure. Values in bold represented that the specific mortality rates were significant for linear trend test ($P < 0.05$)

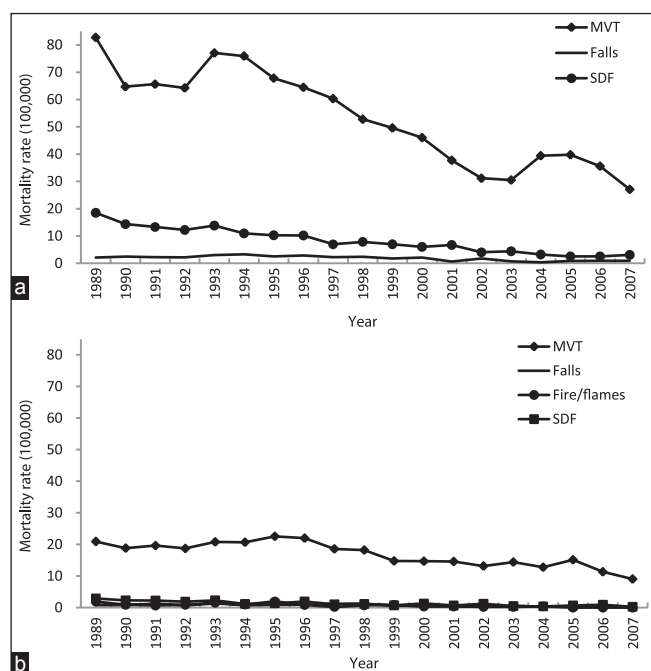


Figure S6: Mortality rates of leading intentional injuries of ages 15-19. (a) Boys (b) Girls. As the ages get older, motor vehicle traffic became the only one leading injury causes of death in both genders as compared with ages <15

significantly in girls in Taiwan. Suicide trends of ages 15-19 showed a U-shaped pattern during 1989-2007. The U-shaped temporal pattern of suicide deaths has been observed in many countries. A ubiquitous period effect exists on suicide mortality in both genders and across all ages. For instance, suicide mortality in ages 10-17 decreased in 1996-2003 and then rose in the US from 2004 to 2005.¹² Risk factors contributing to the suicide rate were social and economic variables, such as the degree of social support, divorce rate, family integration, unemployment, and economic fluctuations, etc.¹³ The decreased suicide trend in ages 15-19 in the early period of 1989-2007⁵ may be indirectly-related to the low unemployment rate <2% from 1985 to 1995; however, unemployment rates increased steadily afterward in Taiwan.⁹

Mortality trends of homicide increased gradually in subgroups of ages <1, 1-4, and 5-9 and were significant in girls aged 1-4 and 5-9. In contrast, the general homicide mortality of the age group 10-19 decreased with time and was significant in boys aged 15-19. The homicide rates show a U-shaped pattern among ages 0-17, similar to those of other countries, and echoed the present finding that ages of 0-4 and 15-19 were at higher risk. Most homicides of children are committed through physical abuse or neglect by family members. In general, boys had a higher risk of being victims of homicide than did girls.¹⁴ However, the present study indicated that girls aged 0-9 years were the high-risk group for homicide; however, in ages 15-19, both girls and boys turned out to be the high-risk group. The

gender difference of homicide mortalities may be due to the different causes of homicide.

Psychiatric disorders¹⁰ accounted for up to 80-90% of adolescent suicide victims and attempters.¹⁵ Family factors, such as family discord, loss of parents, poor parent-child relationship, and maltreatment, etc., are associated with an increased risk of adolescent suicide.¹⁵ Wan and Leung studied Hong Kong youth's suicide attempts and found that family factors, poor family relationship, psychopathology, suicide ideation, and life stressors were significant predictors of suicide ideation and attempts.¹⁶ Media coverage of crimes against children has heightened public alertness of child safety issues and resulted in a number of policy initiatives, but it has not effectively curbed the rise of homicide in children ages 0-9 in recent years.

Given that the risk factors of suicide mentioned above are predictable and preventable, a strategy of preventive efforts and caring for at-risk teenagers must be carried out ahead of time.¹⁷ The study by Boudreaux and Lord showed that parents and relatives were major perpetrators of homicide. Law enforcement and social service workers who identify, investigate, and help child victims play a significant role in prohibiting child homicide. For a more comprehensive prevention strategy of suicide and homicide in children and youth, protective efforts must involve multiagency and multidisciplinary collaboration in the future.¹⁸

Decline in unintentional injuries

The age-adjusted mortality trends of total injuries declined significantly in ages 0-4, 5-9, 10-14, and 15-19 of both genders from 1989 to 2007 [Supplemental Table S2]. Peaks which appeared in 1999 were caused by the large scale earthquake of September 21, 1999 in Taiwan.⁵

In different genders and subgroups of ages, the decline in mortalities caused by intentional injuries was all mainly due to the significant decreasing trends of MVT and SDF. The mortalities of other injuries generally did not change much from 1989 to 2007. However, the mortalities of intentional injuries decreased. Their PMRs, though, still accounted for a high of 35% in boys and a high of 24% in girls in 2007 [Supplemental Figure S1]. However, they only accounted for 10% and 6% in males and females of all ages, respectively.

In Taiwan, MVT is an important problem in youth injuries, especially in ages 15-19. MVT prevention efforts should focus more on this vulnerable age group.⁶ Li showed that the PMR of MVT in ages 15-24 was the highest of all of the age groups of children in 2001; this corresponded to our finding.¹⁹ Compulsory motorcycle helmet use was enacted in 1997, drunk driving law was implemented in 1999, and child restraints (or child car seats) have been required since

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Table S2: The death number and age-adjusted mortality rates per 100,000 of 8 subgroups stratified by genders and ages in 1989-2007

Year	Boys								Girls							
	0-4		5-9		10-14		15-19		0-4		5-9		10-14		15-19	
	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate	<i>n</i>	Rate
1989	436	52.4	252	24.7	288	28.9	1235	131.2	341	44.4	131	13.7	146	15.4	316	35.3
1990	411	49.3	222	22.3	304	29.6	961	103.8	277	35.8	133	14.3	126	12.9	272	30.8
1991	431	51.1	210	22.2	243	23.4	951	103.1	297	38.2	123	13.9	120	12.3	275	31.1
1992	401	47.6	168	18.7	255	24.6	977	104.1	288	37.3	104	12.4	116	11.8	257	28.6
1993	314	37.5	171	19.6	277	26.6	1119	116.1	259	33.6	100	12.2	130	13.2	282	30.7
1994	330	39.9	158	18.5	264	25.7	1120	113.0	233	30.6	78	9.8	117	12.0	282	29.8
1995	302	36.9	128	15.4	220	21.7	1022	100.4	226	30.0	70	9.0	121	12.6	324	33.6
1996	268	32.6	122	14.6	204	20.9	996	97.1	219	28.9	63	8.2	113	12.6	296	30.5
1997	235	28.4	99	11.7	137	14.8	890	86.3	192	25.4	66	8.5	87	10.2	263	27.0
1998	246	30.7	116	13.7	161	18.1	846	82.1	167	22.6	68	8.8	91	10.9	272	28.0
1999	287	36.9	151	17.9	188	21.9	775	76.3	215	30.1	134	17.2	120	15.2	265	27.6
2000	191	25.0	83	9.8	103	12.4	672	67.8	140	20.0	58	7.5	68	8.8	217	23.2
2001	170	22.8	89	10.6	90	10.8	563	59.0	131	19.3	57	7.3	53	6.9	206	22.9
2002	146	20.7	52	6.1	69	8.1	437	47.6	134	20.9	41	5.3	49	6.3	175	20.6
2003	156	23.0	74	8.9	67	7.8	386	44.2	108	17.6	58	7.6	45	5.8	165	20.2
2004	124	19.7	60	7.5	62	7.3	462	55.3	93	16.4	39	5.3	39	5.0	141	18.1
2005	112	18.6	50	6.3	74	8.7	433	53.2	72	13.3	35	4.8	44	5.6	169	22.2
2006	98	17.3	53	6.9	79	9.4	401	48.7	69	13.5	32	4.6	31	4.0	122	16.0
2007	89	16.2	38	5.3	51	6.1	316	37.7	54	11.0	29	4.4	27	3.4	107	13.8
Average	250		121		165		766		185		75		86		232	
Decline proportion		0.69		0.79		0.79		0.71		0.75		0.68		0.78		0.61
Annual change rate		-2.06		-1.37		-1.65		-0.61		-1.05		-4.80		-0.54		-1.01
Lower 95% CI		-2.36		-1.61		-1.86		-0.77		-1.22		-5.58		-0.74		-1.21
Upper 95% CI		-1.76		-1.13		-1.45		-0.45		-0.88		-4.03		-0.33		-0.80
<i>P</i> for trend		**		**		**		**		**		**		**		**

***P* < 0.001, trend test using linear regression; Rate = Age-adjusted mortality rates (100,000) to US 2000 standard population

2002. This series of regulations was a great milestone in the prevention of MVT. They decreased the head injury, severe injury impact, and length of stay.²⁰ However, these regulations did not explain why MVT mortality rates decreased began from 1989.⁶

Mortality of SDF declined with the rate of 0.53/100,000/year (test for trend: *P* < 0.001) in Taiwan, 1989-2007. The mortality rates of SDF were dramatically high in infants (18.7/100,000 in 2007) and most were caused by suffocation. US infant mortality trends attributable to accidental suffocation and strangulation (ICD-9-E code: 913) in bed increased from 2.7 to 13.5/100,000 and from 1984 to 2004.²¹ It suggested that a safe environment in bed was important for the prevention of suffocation and strangulation in infants. However, those trends decreased in Taiwan from 1989 to 2007. This may be

attributed to the educational campaign of baby care for parents and babysitters.

Taiwan has the third highest drowning incident rate in the world,²² which was the major cause of SDF deaths in children aged <19 years.²³ In 2004, approximately 175,000 children and youth aged <20 died as a result of drowning around the world.³ Over half of the global mortality and 60% of the total number of disability-adjusted life years lost due to drowning occurs among children aged between 0 and 14 years.²⁴ Taiwan is surrounded by oceans. Therefore, it is important to implement and incorporate drowning prevention programs into Taiwan's Children and Adolescent Safety Implementation Program.⁶ After many years' efforts since 1978 from Taiwan's government and private social organizations,²⁵ the deaths caused by drowning have decreased from 1989 to 2008.

Wang reported that the warning signs, life-saving stations, life-saving facilities, and life-saving measurements (i.e., cardio-pulmonary resuscitation) in the dangerous aqueous areas, can effectively decrease deaths from drowning.²⁶

The unintentional injury mortality rate in Taiwan (16 and 15/100,000 for ages 0-19 in 2002 and 2005) was lower than Lithuania's (55/100,000 for the ages of 0-19 in 2005)²⁷ but higher than Sweden's (7/100,000 for the ages of 0-20 in 2002).²⁸ In terms of total deaths caused by injury, Taiwan's (10 and 17/100,000 for ages 0-14 and 0-19) was lower than Finland's (26/100,000 for ages 0-19)²⁹ but higher than Canada's (7/100,000 for ages 0-14)³⁰ in 2002. Sweden had the lowest child injury mortality rate in the world, 5.2/100,000 for children under 15 years in 2001,²⁸ while Taiwan was 11/100,000 which is about 1 time larger than Sweden's. Though the injury mortality trend was declining in Taiwan, there was still room for improvement.

In 1989-2007, MVT and SDF were the major leading causes of injury death in ages 0-19. This was similar to the reports of US,³¹ UK,³² Europe,³³ New Zealand,³⁴ and Canada,³⁰ and their mortality rates were much higher than those stemming from other injuries. Chien *et al.* reported the same results in Taiwan.⁶

Gender difference

The morality rankings of injuries by genders were similar under 4 years, as the age increasing the rankings in genders differed. In general, boys had a higher risk than girls who died from injuries in ages 0-19 in 1989-2007. The average mortality rates for total injuries of ages ≤ 15 were not statistically different by gender, but turned out to be significant in ages 15-19, in that the boys' was 2.1 times greater than the girls'. Lai *et al.* also reported that the boys' injury mortality rates were 2.2 times greater than the girls' in ages 15-19 in Taiwan from 1986 to 2007.⁵ From birth onward, boys have higher injury mortality rates than girls, for all types of injuries in developed countries.³⁵ The pattern is less uniform in low-income and middle-income countries, but the overall gender differential is obvious, with mortality rate of injuries around one-third higher for males under 20 years than for females.³

CONCLUSION

During the period of 1989-2007, there were large decreases in childhood mortality rates for total and unintentional injuries, especially for MVT and SDF. Intentional injuries were responsible for 6% of all injuries in ages of 0-19, of which suicide and homicide ranked in the top seven causes of injury death. These accounted for 3% of the deaths in children of the at-risk ages of 10-19 and 0-9, respectively. Boys were at a higher risk of dying from suicide than girls and an increasing suicide

trend was observed in aged 15-19. As to homicide, mortality trend were increasing in children aged <9 and significant for trend test in girls aged 1-9. Injury causes of death varied with genders and ages. This is especially obviously for older youth; hence, the focus of an injury prevention program aimed at older youth should be different than that of one designed for younger ones.

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