ORIGINAL ARTICLE

Child drowning deaths in Xiamen city and suburbs, People's Republic of China, 2001–5

Ya Fang, Long Dai, Michael S Jaung, Xiaoxuan Chen, Songlin Yu, Huiyun Xiang

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See end of article for authors' affiliations

Correspondence to: Dr Ya Fang, Department of Preventive Medicine, College of Medicine, Xiamen University, Xiamen, China; fangya@xmu.edu.cn or Dr Huiyun Xiang, Center for Injury Research and Policy, Columbus Children's Research Institute, Columbus, Ohio, USA; xiangh@ccri.net

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Background: Risk-factor research and prevention programs targeting drowning deaths in children have been well developed in industrialized countries, but little research has been undertaken in developing countries where the majority of drowning deaths occur. We conducted an epidemiological study to describe the sociodemographic characteristics, drowning circumstances, and medical service in drowning deaths of children in Xiamen city and suburbs, People's Republic of China.

Material and methods: Drowning deaths in 1–14-year-old children between 2001 and 2005 were identified using death certificates. Parents of each case were interviewed face to face about the sociodemographics of the family and child, the drowning event, and medical care received. Mortalities were calculated using census data for urban and rural areas, and Poisson regression was used to evaluate confounding effects and interactions of several major risk factors for drowning death.

Results: Of 67 drowning deaths identified, 52 (77.6%) were males. A higher proportion of deaths were in children aged 5–9 years (40.3%) and 10–14 years (40.3%). The drowning mortality per 100 000 population was 5.84 in rural areas and 0.75 in urban areas. Drowning events occurred most commonly during the summer months (56.7% from June to August), during the hours of 13:00–17:59 (62.7%), and in natural or man-made bodies of water (eg, ponds, ditches, construction sites, and wells). None of the children were proficient swimmers, the majority of drowning events (88.1%) occurred in the absence of adult supervision, and 86.6% children died at the scene without any medical care. Results from multivariable Poisson regression analysis indicated that 10–14-year-old boys were at the highest risk of drowning deaths in this area.

Discussion and conclusions: Drowning deaths in children in Xiamen city and suburbs follow trends that are markedly different from patterns observed in other countries. Different prevention strategies may be required for preventing child drowning deaths in Xiamen and other developing regions.

Drowning is a major cause of death among children worldwide. Of the 500 000 drowning mortalities estimated globally in 1998, 57% were among children less than 15 years of age, and 97% occurred in low- and middle-income countries.¹ Despite the high occurrence of child drowning deaths in developing countries, research and prevention strategies have been largely confined to only industrialized countries. Regional studies in the United States, Australia, and the UK have indicated that both the relative risk and location of child drowning deaths are associated with age, gender, race, and utilization of prehospital care.^{2–10}

In developing countries, drowning deaths have been poorly described in school-age and adolescent children, and previous studies indicate that the risks of drowning are specific to both regions and countries.^{11–13} In Guadalajara, Mexico, underground cisterns were the most prevalent site of drowning incidents in children aged 1–4.¹² In contrast, a study in Bangladesh found that drowning deaths were largely a consequence of exposure to natural bodies of water, and mortality was associated with the age and literacy of the mother as well as household income.¹³ A recent study of risk factors for childhood drowning deaths in inland Guangxi province of China suggests that the lack of constant supervision, proper swimming lessons, and flotation device use when swimming are significant risk factors for childhood drowning death.¹¹ Thus, in the interest of saving lives, research on drowning patterns is essential to developing effective prevention strategies in the regions of the developing world where drowning is a large burden.

Child drowning deaths in China and the western Pacific region is a particular problem.¹¹ Over one fifth of all drowning deaths in the world are estimated to occur in China.¹⁴ In the

WHO survey of the disease burden of injury, China was the only country in which drowning ranked in the top 15 causes of both death and total burden of disease among all ages.¹⁵ In 2002, half of all drowning deaths in China occurred among children under 15 years of age. Death from drowning was ranked as the leading cause of mortality among children aged 5–14 and the sixth leading cause of death in children aged 0–4.¹⁶ Drowning was also the highest contributor to the burden of disease in children aged 5–14 and the ninth leading cause for children less than 5 years of age. It is estimated that the mortality of drowning in children aged 1–14 is 4.5–10 times greater in rural areas than in urban areas.¹⁴ Despite the high prevalence of pediatric drowning deaths in China, the sociodemographic and circumstantial factors in these deaths have not been well characterized, especially in rural areas.

In this study, we sought to examine the drowning deaths of children aged 1–14 in the rural and urban areas of the sub-provincial city of Xiamen in the southwestern coastal region of the People's Republic of China. Using a retrospective analysis of death certificates, we identified drowning deaths from 2001–5 and completed interviews with the victims' family to describe characteristics of the victim and drowning death as well as to examine patterns of drowning events and utilization of medical services.

METHODS

Study setting and drowning case identification

Xiamen is a sub-provincial city of the Fujian province, on the southeastern coast of the People's Republic of China. It is divided into six districts with a total population in 2005 of 1.5 million with 0.69 million and 0.84 million living in urban and

rural areas, respectively (Xiamen Bureau of Population Statistics).

Drowning deaths in 1–14-year-old children that occurred in Xiamen between 1 January 2001 and 31 December 2005 were identified by searching the death certificate database maintained by the Xiamen Center for Disease Control. An official death registry system was established several decades ago in China, and it adopted the International Classification of Diseases. The identification of drowning cases in our study followed the International Classification of Diseases, 9th Revision (ICD-9) diagnosis code 994.1 before 2002 and 10th Revision (ICD-10) diagnosis code W65–W74 after 2002 (Drowning and nonfatal submersion, bathing cramp, or immersion).¹⁷ Near-drowning and nonfatal drowning incidences were not examined in this study. After drowning death cases were identified, the contact information (name of the child, name of parents or care givers, city or village address) of drowning death cases was printed for each of the drowning victims. This contact information was compiled and used in the subsequent questionnaire survey among parents.

Parents' interview

A short survey questionnaire (22 questions) was used to collect further information related to the drowning deaths and drowning events. Based on the literature review and the objectives of our study, the survey questionnaire collected information on the following domains: demographics of the drowning victims (name, gender, age, school years); characteristics of the family (mother's age and school years, father's age and school years, number of children in family, household monthly total income in Chinese Yuan); characteristics of the drowning event (location of drowning, month in which drowning occurred, day and time of drowning, presence of adult supervision when drowning event occurred); and emergency response and medical treatment (first-aid treatment, location of formal treatment, hours between drowning events and death).

Face-to-face interviews were conducted at the parent's house by district health professionals who were trained by our study research members at the Department of Preventive Medicine, College of Medicine, Xiamen University who have expertise and many years of experience in designing and conducting population-based epidemiological surveys. A total of six health professionals, one from each of the six districts of Xiamen, received the formal training and conducted the household parents' survey for our study. During the training workshop, questions in the survey questionnaire were discussed among the workshop participants and researchers. Minor changes were made to a few questions based on the feedback and suggestions of the district health professionals.

Drowning cases identified through death registry database were grouped by the district of their family residence and the detailed contact information was provided to the health professional who was responsible for conducting the interview in their district. As the education level of parents was generally not high, the survey questionnaire was completed by the health professional who conducted the household survey. After the interview, health professionals submitted the survey forms to Dr Ya Fang who conducted a quality review. If information was missing for any of the questions in the survey questionnaire, it was sent back to the district professional, who was asked to go back to collect the remaining information.

The study was approved by the College of Medicine, Xiamen University, and informed consent was obtained from all parents before the data collection. Detailed information about the purpose of the survey, procedures, protection of confidential survey and medical information, and the dissemination of study results was explained clearly to the parents, and

particular care was taken to minimize the discomfort experienced by parents of the victims.

Statistical analysis

All survey data were entered into an Excel database, and a de-identified research database was created by Dr Fang's team at Xiamen University. The de-identified database was then provided to Dr Xiang's team at the Center for Injury Research and Policy, the Ohio State University, USA, for final statistical analysis.

Final data analysis was conducted using SAS statistical software version 9.1.¹⁸ Basic statistics were used first to identify sociodemographics of drowning victims, characteristics of drowning events, and medical treatments. Mortalities were then calculated using the census data for urban and rural areas of the study site. Rural and urban populations were defined by the district of Xiamen where they resided. Using the dates of birth and death for each child that were obtained from the death certificates, age in years was categorized as 1–4, 5–9, and 10–14 to correspond with census divisions. No data were obtained for children aged less than 1 year. Rates for urban and rural drowning mortality were calculated per 100 000 person years, and 95% confidence intervals of mortalities were provided. Finally, a Poisson regression model was used to analyze simultaneously the impact of important factors including year of drowning, residence, gender, age of the victim, and interaction of gender and age on the relative risk of drowning deaths. In building the Poisson regression model, drowning death data and population data were compiled together by the year in which drowning death occurred, residence, gender, and age of the victim. Drowning deaths were considered rare events in the context of the large Xiamen population; thus, the distribution of drowning deaths among children could be considered to follow the Poisson distribution. Variables with a *p* value less than 0.05 were considered statistically significant.

RESULTS

Our study identified 67 drowning deaths in children aged 1–14 years in Xiamen from 2001 to 2005. Sociodemographic characteristics collected from the family interviews are shown in table 1. Among these drownings, 52 (77.6%) were male victims, and 15 (22.4%) were females. Grouped by age, a higher proportion of deaths were in children aged 5–9 years (40.3%) and 10–14 years (40.3%) than 1–4 years (19.4%). Most victims (62.7%) were in primary school at the time, and only 17% and 8% were not in school or in junior high school, respectively. The majority of drowning deaths occurred among children residing in rural areas (91.0%) vs. urban areas (9.0%). Thirty-nine percent of deaths occurred in households with a low income of <1000 yuan/month, and an additional 32% in households with an income of <3000 yuan/month.

The drowning events occurred most commonly during the months of June to August (56.7%). The type of day (weekday, weekend, holiday, or summer break) indicated that the majority of drowning deaths (43.3%) occurred during school breaks or summers. Most of the drownings were during the hours of 13:00–17:59 (42, 62.7%), and 95.5% were between the hours of 0:00 and 17:59. Seventy-two percent of drownings in all age groups occurred in natural bodies of water (ponds, ditches, rivers, reservoirs, and lakes). Man-made bodies of water (construction sites and wells) accounted for 23.8%, and only 3.0% of the deaths were at home. Only one (1.5%) drowning death occurred in a bathtub at home, and child abuse was not suspected in any of the cases observed. None of the children were proficient swimmers, and 41 (75.9%) of children aged five and older had no swimming ability. Fifty nine (88.1%)

Table 1 Characteristics of drowning victims aged 1–14 and drowning events by proportion and percentage in Xiamen, People's Republic of China, 2001–5

Characteristic	Cases (n = 67) (%)
Gender	
Male	52 (77.6)
Female	15 (22.4)
Age (years)	
1–4	13 (19.4)
5–9	27 (40.3)
10–14	27 (40.3)
School level	
None	17 (25.4)
Primary school	42 (62.7)
Junior high school	8 (11.9)
Residence	
Urban	6 (9.0)
Rural	61 (91.0)
Household income*	
<1000	26 (38.8)
1000–2999	32 (47.8)
≥3000	9 (13.4)
Month of drowning	
December to February	6 (9.0)
March to May	11 (16.4)
June to August	38 (56.7)
September to November	12 (17.9)
Type of day	
Weekday	19 (28.4)
Weekend	13 (19.4)
Holiday	6 (9.0)
Summer break	29 (43.3)
Time of day	
0:00–12:59	22 (32.8)
13:00–17:59	42 (62.7)
18:00–18:59	1 (1.5)
19:00–23:59	2 (3.0)
Location	
Pond	20 (29.9)
Ditch	14 (20.9)
Construction site	8 (11.9)
Well	8 (11.9)
River	7 (10.4)
Reservoir	6 (9.0)
Home	2 (3.0)
Lake	1 (1.5)
Other	1 (1.5)
Swimming ability†	
None	41 (75.9)
Some	13 (24.1)
Proficient	0 (0.0)
Adult supervision	
Parent	2 (3.0)
Adult	6 (9.0)
None	59 (88.1)

*Household income measured in yuan/month; †excludes children aged 1–4 years.

gender and age. The final results are listed in table 3. The mortality in children residing in rural areas was $\exp(2.060) = 7.845$ times greater than those in urban areas. Gender and age also had a statistically significant interaction, and boys aged 10–14 years had the highest relative risk in comparison with other groups (RR = 5.398, 95% CI = 1.053 to 26.677, $p = 0.043$).

DISCUSSION

Results from our study indicate that trends in child drowning deaths in Xiamen, People's Republic of China are different from previously studied regions in industrialized and developing countries. While the higher proportion of male deaths to female deaths corresponds with other studies, our data indicate that there was a much higher proportion of drowning deaths in children aged 5–14 than children aged 1–4. This is also reflected in the results from the multivariable Poisson regression model that boys aged 10–14 years had the highest relative risk in comparison with other groups. This trend is in sharp contrast to the predominance of drowning deaths in children aged 1–4 previously observed in the United States, Australia, and Bangladesh,^{3 8 13 19 20} and a recent study of childhood drowning deaths in inland Guangxi province of China.¹¹ The drowning rate of children aged 5–14 years in this study was nearly twice as high as children aged 1–4, an opposite trend from that observed in the United States and Australia where data were available (table 4).^{19 20}

The high proportion of drowning deaths in children residing in low-income, rural households reflects the sociodemographic differences of developed countries such as the United States with China and other developing countries. In a study in King County, Washington State, there was not a wide disparity in the percent and rate of drownings between rural and urban locations.⁹ In our study, mortalities based on socio-economic status were not calculated from lack of census data. Our study provided new evidence to reinforce the findings from previous reports that compared mortalities of urban and rural child drowning deaths in developing countries.

Analyzing other underlying risk factors in child drownings, previous studies in Bangladesh found a higher risk of mortality in households with older mothers and more children.^{2 13} However, in this study, there was no pattern seen in the size of the household, age, or education of either the father or mother (data not shown). There were also no victims that had been identified with a previous history of seizures. Children with this underlying medical condition have been shown to have an increased likelihood of drowning death.¹⁹ Finally, the lack of swimming ability is expected in a region where swimming lessons are rare, but whether this directly contributes to the high mortalities remains uncertain. Previous studies have shown that a higher swimming ability may even increase the risk of drowning death.^{21 22}

The distribution of drowning death sites also differs from previously studied regions. In contrast to developed countries where deaths in private swimming pools account for about a third of deaths in children aged 0–14, no deaths were reported in swimming pools in Xiamen in our study.^{4 7 9} Instead, 96% of drowning deaths in children of the ages studied occurred in natural and man-made bodies of water including ponds, ditches, construction sites, wells, reservoirs, and rivers. This reflects the high exposure of children in rural areas to these types of water hazards and their limited exposure to swimming pools concentrated in urban areas. Also differing from drowning patterns observed in the developed countries, only two deaths occurred within the home. These differences in drowning patterns must be considered when implementing prevention strategies. Temporally, the trends of drowning

events occurred in the absence of both parental and adult supervision.

The overall mortality from drowning in Xiamen during the study period was 3.62 per 100 000 population years (95% CI: 3.47 to 3.78). The majority of drowning deaths occurred among children residing in rural areas (91.0%) vs. urban areas (9.0%). The calculated drowning mortality in rural areas (5.84; 95% CI: 5.63 to 6.05) was over 7.8 times greater than in urban areas (0.75; 95% CI: 0.56 to 0.93) per 100 000 person years.

Analyzing medical care, 58 (86.6%) deaths occurred at the site of the drowning before formal treatment, and 45 (67.2%) children received no first aid (table 2). Only 5% were treated at a hospital or clinic, and only 15% received either rescue breathing or cardiopulmonary resuscitation (CPR) at the site.

A Poisson regression model was used for multivariate analysis of year, residence, gender, age, and the interaction of

Table 2 First-aid and medical treatment of drowning deaths in children aged 1–14 in Xiamen, People's Republic of China, 2001–5

Characteristic	Cases (n = 67) (%)
First aid treatment	
Treatment for choking	12 (17.9)
Rescue breathing	4 (6.0)
CPR	6 (9.0)
None	45 (67.2)
Location of formal treatment	
Died at scene without treatment	58 (86.6)
Treatment at scene	6 (9.0)
Clinic	1 (1.5)
Hospital	2 (3.0)

events follow those found previously in Bangladesh and in China: the majority of drowning deaths occurred during the daylight hours and the warmer months from June to August.^{2 11} The significant decrease in mortalities in 2005 compared to 2001–4 was unanticipated, and its causes are unknown. This trend may be attributed to changes in temperature or rainfall and warrants further study. Finally, the overwhelming majority (88%) of drowning deaths that occurred in Xiamen were in the absence of a parent or another adult, a trend that is shared with drowning patterns in the United States, Bangladesh, and inland Guangxi province.^{2 4 11 23} Before the incident, children were generally playing in the water, swimming, or walking by the water without any adult supervision. This lack of supervision may have contributed to the lack of effective rescue when drowning events occurred as well as the low proportion of children that received first aid and medical treatment. It has been shown previously that factors in prehospital care were the best predictors of outcome, and prompt care may decrease mortality.²⁴

Through family interviews, this study was able to ascertain the surrounding causes of the child drowning deaths identified. However, the study was limited to only child drowning deaths recorded by death certificates by the Xiamen Center for Disease Control. There is an under-reporting possibility that some child drowning deaths, particularly in infants, were not reported. In the United States and Australia, it has been found that drowning mortality is more than 35% higher than actually

Table 4 Comparison of child drowning rate by age group in various countries

Location	Drowning rate children aged <5	Drowning rate children aged 5–14
Xiamen, China	3.68	6.89
Washington State, USA*	3.1	1.2
Australia, excluding Northern Territories†	3.71	0.62

*19, †20.

reported.²⁵ The burden of new-drowning events was not studied here because of a lack of a reporting system in China. All of these limitations might have resulted in an underestimation of the severity of the drowning epidemic in the region we studied. The small sample size and nature of the data limited the multivariate analysis to demographic characteristics. Although the trends identified may be regionally specific, Xiamen is similar to other coastal communities in China and other less-developed countries; therefore, implications for drowning prevention should be generalizable to these regions.

Implications for drowning prevention

The drowning patterns described in this study suggest possible prevention strategies that differ from those used in developed countries. The implementation of pool fencing and parent education during swimming lessons has been shown to be moderately effective.^{26–29} However, neither of these prevention strategies would prove applicable in Xiamen and other parts of developing countries due to the lack of swimming pools and swimming-lesson programs. Based on trends found in this study, monitoring and fencing of natural bodies of water and education programs among parents to increase adult supervision of children in summer could possibly prevent more child drownings. Additionally, education in schools of the hazards of swimming may decrease drowning mortality. In Imperial County, California, the low rate of mortality in water canals may have been attributed to the canal safety programs in county schools.²³ The overall burden of and factors contributing to pediatric drowning deaths have been severely understudied in China, and we hope that information from this study can be used to design effective prevention strategies to begin to address this large-scale problem.

Table 3 Poisson regression model of major risk factors for drowning death in children aged 1–14 in Xiamen, People's Republic of China, 2001–5

Factor	Regression parameter estimate	SE	p value	RR (95% CI)
Year				
2001*	–	–	–	1.000
2002	–0.141	0.374	0.707	0.869 (0.418 to 1.807)
2003	–0.020	0.360	0.956	0.980 (0.484 to 1.986)
2004	–0.306	0.385	0.428	0.737 (0.346 to 1.567)
2005	–1.365	0.526	0.010	0.255 (0.091 to 0.716)
Residence				
Urban*	–	–	–	1.000
Rural	2.060	0.428	<0.0001	7.845 (3.389 to 18.060)
Gender				
Male	0.049	0.633	0.938	1.050 (0.304 to 3.627)
Female*	–	–	–	1.000
Age				
1–4*	–	–	–	1.000
5–9	0.034	0.606	0.956	1.034 (0.316 to 3.389)
10–14	–0.203	0.671	0.762	0.816 (0.219 to 3.039)
Gender and age				
Male 5–9	1.312	0.779	0.092	3.714 (0.807 to 17.092)
Male 10–14	1.686	0.834	0.043	5.398 (1.053 to 27.677)

*Reference group.

Key points

- Similar to other research in developing countries, overall drowning mortality is significantly higher in rural areas than in urban areas
- In contrast to other studies in industrialized and developing countries, older boys are over-represented in this coastal southern region of China
- Drowning events occurred mostly in natural or man-made bodies of water (eg, ponds, ditches, construction sites, and wells)
- Prevention strategies should include monitoring and fencing of natural bodies of water and education programs among parents to increase adult supervision

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Authors' affiliations

Ya Fang, Xiaoxuan Chen, Department of Preventive Medicine, College of Medicine, Xiamen University, Xiamen, China

Long Dai, Division of Chronic Diseases, Xiamen Center for Disease Control, Xiamen, China

Michael S Jaung, Songlin Yu, Huiyun Xiang, Center for Injury Research and Policy, Columbus Children's Hospital and Children's Research Institute, College of Medicine and Public Health, Ohio State University, Columbus, USA

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HUMAN PARTICIPANT PROTECTION

Institutional review board approval was granted by Xiamen University to Dr Ya Fang, who originated the study questions and led the data-collection efforts in China. De-identified data (no identifiable information at all) were transferred to Dr Huiyun Xiang's team at Center for Injury Research and Policy, The Ohio State University for further statistical data analysis and manuscript writing. All authors made substantial contributions to the published work.

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