



Analysis of National Major Work Safety Accidents in China, 2003-2012

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Abstract

Background: This study provides a national profile of major work safety accidents in China, which cause more than 10 fatalities per accident, intended to provide scientific basis for prevention measures and strategies to reduce major work safety accidents and deaths.

Methods: Data from 2003-2012 Census of major work safety accidents were collected from State Administration of Work Safety System (SAWS). Published literature and statistical yearbook were also included to implement information. We analyzed the frequency of accidents and deaths, trend, geographic distribution and injury types. Additionally, we discussed the severity and urgency of emergency rescue by types of accidents.

Results: A total of 877 major work safety accidents were reported, resulting in 16,795 deaths and 9,183 injuries. The numbers of accidents and deaths, mortality rate and incidence of major accidents have declined in recent years. The mortality rate and incidence was 0.71 and 1.20 per 10⁶ populations in 2012, respectively. Transportation and mining contributed to the highest number of major accidents and deaths. Major aviation and railway accidents caused more casualties per incident, while collapse, machinery, electrical shock accidents and tailing dam accidents were the most severe situation that resulted in bigger proportion of death.

Conclusion: Ten years' major work safety accident data indicate that the frequency of accidents and number of deaths was declined and several safety concerns persist in some segments.

Keywords: Work safety, Major accident, Prevention

Introduction

Five of the world's most fatal work safety accidents in the past decade (2001-2010) occurred in China (1). Work safety accidents has become the first cause of deaths of Chinese citizens below 44 yr old (2). Work safety accidents pose a great threat to people's life, especially major accidents, defined as ones that result in at least 10 deaths. The Chinese government has established a surveillance system for monitoring work safety accident since 2001 under State of SAWS (3), which is the only authority system for work safety accidents inquiry in China.

Injuries related to transportation, mining, fire, explosion had the majority of occurrence (4-6), and the most accidents occurred in construction on certain geographic regions of China (7, 8). Previous researches had focused on the characteristics of work safety accidents, while there is very few research analyzing major accidents with mass casualties. There has no clear answer yet that whether accidents with mass casualties are a simple enlargement of general accidents, or there is inherent mechanism of accident cause and special risk factors or not. The in-depth research focused on

cause mechanism of work accidents with at least 10 fatalities has important theoretical value and practical meaning to improve relevance and effectiveness of accident prevention.

To examine the national profile of the extent and type of major accidents in work safety, which causes more than 10 fatalities per accident, we analyzed data from accident inquiry system on SAWS website for the period 2003 to 2012 and provide scientific basis for prevention measures and strategies to reduce major work safety accidents and deaths in China.

Materials and Methods

Source of Data

Data from the State SAWS corresponding to the period 2003-2012 were used in this analysis. SAWS is the competent agency under the State Council in charge of the comprehensive supervision and administration of work safety and coalmines of the whole country. China has made mandatory provisions focusing on the implementation of safety standards, risk forecasting, accident reporting, accident accountability and other aspects through the development of relevant laws and regulations, departmental regulations and safety standards. The SAWS is law-based administration to strengthen the comprehensive supervision and administration of work safety and coal mines of the whole country. The SAWS collects information from provinces, cities and local data sources, including details regarding fatal accidents with more than three deaths and non-fatal injuries, and associated economic losses. The information of work safety accidents and coalmine incidents are required to report from enterprise involved to the regional agency and provincial department, and then finally submitted to the SAWS. After conducting an investigation, the SAWS announces the findings and determines about penalty. In this study, the data covered most industries except the military forces and private enterprises. Additionally, we checked statistical year-book of road traffic accidents and public literature to supplement information and details.

The analysis was conducted using the registered data with more than 10 deaths per incident. Major

accidents in transportation involved victim who was the operator, passenger, or a pedestrian stuck in or on the side of the road.

Data Analysis

After extraction, details including types of the event, year, region, number of deaths and injuries, causes of accidents were transformed into SPSS v13.0 (Chicago, IL, USA). Mortality rate and incidence of major work safety accidents used national census data. We performed analysis on the frequency of accidents and deaths, the trend, geographic distribution and type of major accidents. We analyzed the geographic distribution using hierarchical cluster analysis, focused on the frequency of accidents and deaths.

Incidence of major accident shows the occurrence probability of any person, and major accident mortality shows the dying probability. The incidence and mortality of major accident are defined as follows:

Incidence = number of major accident / (total national population $\times 10^6$)

Mortality = number of death / (total national population $\times 10^6$)

Results

Injuries Distribution by Year

We found a dramatic decline in both numbers of accidents and deaths since 2006. The number of accidents and deaths dropped by 52.0% and 66.6% from the peak year (2005) to 2012, respectively. In the 10-yr period from 2003 to 2012, there were 866 major accidents in work safety in China, resulting in 16795 deaths and 9183 injuries. The incidence of major accident and the mean mortality rate were 1.93 and 1.34 per one million populations annual. In recent years, both the major accident mortality rate and incidence of major accident have declined (Fig. 1).

Injuries Distribution by Geographic Region

Fig. 2 shows major work safety accidents and deaths in relation to their geographic distribution. The deeper the color in the region, the higher

number of accidents and deaths occurred. Using hierarchical cluster analysis, we found that the regions reporting the highest number of injuries and deaths were Hunan (62/936), Guizhou (69/1101),

Henan (54/1302), Shanxi (79/2045), with a total of 264 incidents and 5384 deaths, both accounting for 30% nation-wide.

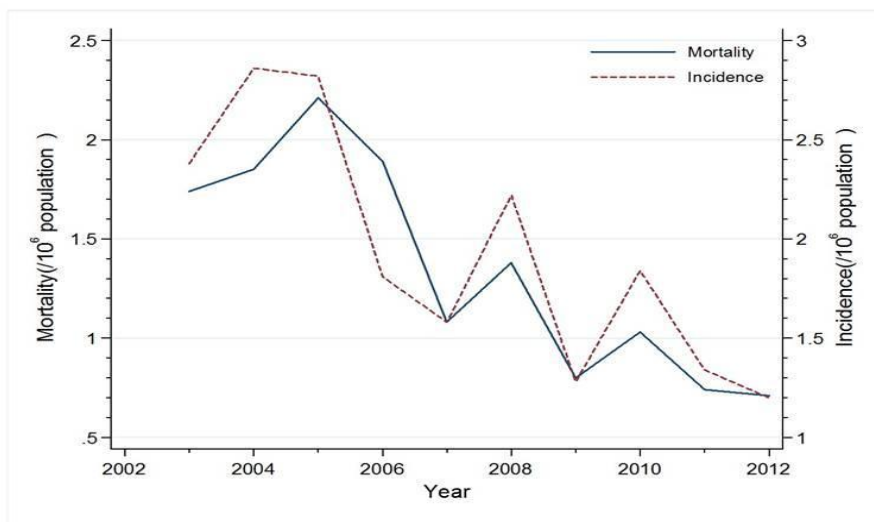


Fig. 1: Mortality rate and incidence of major accidents in work safety in China, by year, 2003-2012

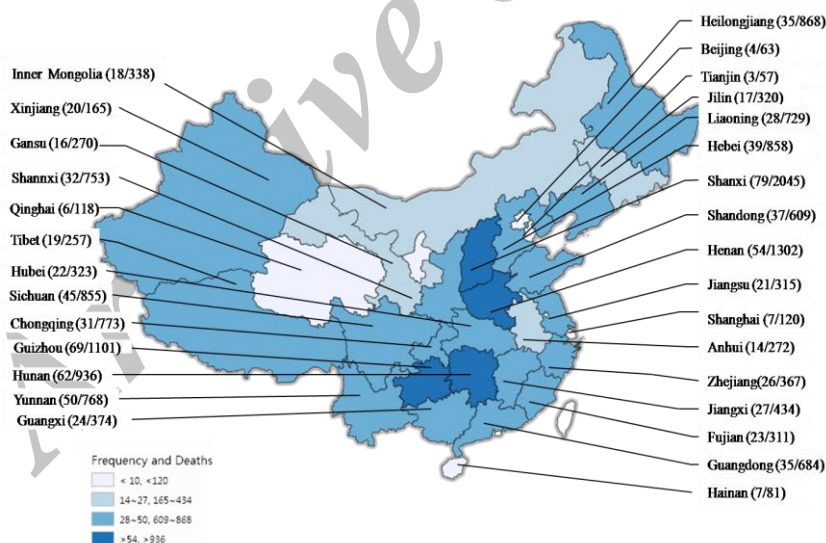


Fig. 2: Geographic distribution of major work safety accidents in China, 2003-2012 (number of incidents/number of deaths)

Injuries by Industry

Transportation-related accident was responsible for the highest frequency of deaths from 2003 to 2012 (n=437). Table 1 shows that transportation and mining caused more injuries and deaths dur-

ing the dates evaluated. The number of injuries declined in the last years, as did the number of injuries caused by all types of industries. However, we have not noticed such a tendency in manufac-

turing, construction and service. Furthermore, mining declined in percentage of injuries, while

percentage of transportation-related accident increased.

Table 1: Type of industry-related accident in China by year, 2003-2012

Year	Manufacturing n (Percent)	Construction n (Percent)	Service n (Percent)	Mining n (Percent)	Transportation n (Percent)	The others n (Percent)	Subtotal
2003	8 (7.6)	2 (1.9)	2 (1.9)	41 (39.0)	52 (49.5)	1 (1.0)	106
2004	9 (7.4)	3 (2.5)	1 (0.8)	37 (30.6)	71 (58.7)	0.0	121
2005	5 (4.1)	3 (2.4)	2 (1.6)	55 (44.7)	58 (47.2)	2 (1.6)	125
2006	8 (8.5)	1 (1.1)	2 (2.1)	40 (42.5)	43 (45.7)	0.0	94
2007	8 (9.8)	6 (7.3)	5 (6.1)	31(37.8)	32 (39.0)	0.0	82
2008	5 (6.0)	4 (4.8)	2 (2.4)	31(37.3)	41 (49.4)	4 (4.8)	85
2009	6 (9.7)	3 (4.8)	1 (1.6)	21(33.9)	31(50.0)	0.0	62
2010	7 (9.2)	3 (3.9)	3 (3.9)	20 (26.3)	43 (56.6)	3 (3.9)	79
2011	7 (11.3)	4 (6.5)	3 (4.8)	18 (29.0)	30 (48.4)	1 (1.6)	63
2012	3 (5.2)	2 (3.4)	2 (3.4)	15 (25.9)	36 (62.1)	2 (3.4)	60
Total	66 (7.6)	31 (3.6)	23 (2.7)	309 (35.7)	437 (50.5)	13 (1.5)	877

Mining contributed to the highest number of deaths (n=7646). From 2003 to 2012, there were 309 mining-related accidents, each of which caused 24.7 fatalities. As indicated in Table 2, more than 80% of major work safety accident-

related deaths occurred in mining and transportation, and both of them declined in recent years. Mining declined starting in 2006, and transportation declined starting in 2005.

Table 2: Number of deaths by industry in China by Year, 2003-2012

Year	Manufacturing n (percent)	Construction n (percent)	Service n (percent)	Mining n (percent)	Transportation n (percent)	The others n (percent)	Subtotal
2003	163 (7.2)	27 (1.2)	53 (2.4)	1168 (51.9)	828 (36.8)	10 (0.4)	2249
2004	139 (5.8)	44 (1.8)	53 (2.2)	998 (41.4)	1174 (48.8)	0.0	2408
2005	80 (2.8)	74 (2.6)	68 (2.3)	1708 (59.0)	943 (32.6)	21 (0.7)	2894
2006	125 (8.0)	11 (0.7)	25 (1.6)	761 (48.8)	638 (40.9)	0.0	1560
2007	129 (9.0)	147 (10.3)	65 (4.5)	616 (43.0)	474 (33.1)	0.0	1431
2008	96 (5.2)	51 (2.8)	55 (3.0)	886 (48.2)	676 (36.8)	75 (4.1)	1839
2009	70 (6.5)	34 (3.2)	11 (1.0)	524 (49.0)	430 (40.2)	0.0	1069
2010	134 (9.7)	32 (2.3)	40 (2.9)	466 (33.8)	633 (45.9)	74 (5.4)	1379
2011	90 (9.0)	58 (5.8)	30 (3.0)	265 (26.5)	542 (54.2)	15 (1.5)	1000
2012	70 (7.2)	39 (4.0)	24 (2.5)	254 (26.3)	535 (55.4)	44 (4.6)	966
Total	1096 (6.5)	517 (3.1)	424 (2.5)	7646 (45.5)	6873 (40.9)	239 (1.4)	16795

Severity of injury

Table 3 displays the number of deaths per accident by industry by year. The average number of death per accident in service and mining shows a decline in recent years, while we have not found the similar trend in manufacturing, construction and transportation. Coal mine-related and road

traffic-related accidents were dominant and nearly accounted for four-fifths of all types of major accidents. The evaluation of all types of accidents has revealed that tailing dam related accident was the most severe in terms of number of fatalities per incident, causing 105 deaths per incident.

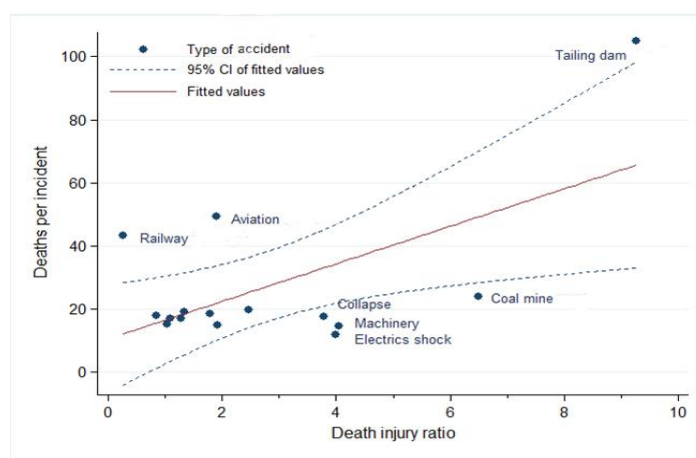
Table 3: Number of deaths per accident by industry in China by Year, 2003-2012

Year	Manufacturing	Construction	Service	Mining	Transportation	The others	Subtotal
2003	20.38	13.50	26.50	28.49	15.92	10.00	21.22
2004	15.44	14.67	53.00	26.97	16.54	0.00	19.90
2005	16.00	24.67	34.00	31.05	16.26	10.50	23.15
2006	15.63	11.00	12.50	19.03	14.84	0.00	16.60
2007	16.13	24.50	13.00	19.87	14.81	0.00	17.45
2008	19.20	12.75	27.50	28.58	16.49	18.75	21.64
2009	11.67	11.33	11.00	24.95	13.87	0.00	17.24
2010	19.14	10.67	13.33	23.30	14.72	24.67	17.46
2011	12.86	14.50	10.00	14.72	18.07	15.00	15.87
2012	23.33	19.50	12.00	16.93	14.86	22.00	16.10
Total	16.61	16.68	18.43	24.74	15.73	18.38	19.15

Table 4: Number of deaths and frequency by type of accidents in China, 2003~2012

Type of injury	Incidents	Deaths	Injuries	Deaths per incident	Death: injury ratio
Coal mine accidents	300 (34.2)	7219 (43.0)	1113 (12.1)	24.06	6.49
Road traffic accidents	362 (41.3)	5536 (33.0)	5011 (54.6)	15.29	1.04
Shipping accidents	60 (6.8)	885 (5.3)	462 (5.0)	14.75	1.92
Fire accidents	51 (5.8)	873 (5.2)	680 (7.4)	17.12	1.28
Fireworks accidents	25 (2.9)	477 (2.8)	360 (3.9)	19.08	1.33
Chemical accidents	26 (3.0)	463 (2.8)	552 (6.0)	17.81	0.84
Collapse	21 (2.4)	368 (2.2)	97 (1.1)	17.52	3.79
Tailing dam accidents	3 (0.3)	315 (1.9)	34 (0.4)	105.00	9.26
Machinery	11 (1.3)	162 (1.0)	40 (0.4)	14.73	4.05
Railway accidents	3 (0.3)	130 (0.8)	615 (6.7)	43.33	0.26
Other mineral accidents	6 (0.7)	112 (0.7)	63 (0.7)	18.67	1.78
Aviation accidents	2 (0.2)	99 (0.6)	52 (0.6)	49.50	1.90
Smelting accidents	5 (5.7)	85 (0.5)	77 (0.8)	17.00	1.10
Dynamite accidents	3 (0.3)	59 (0.4)	24 (0.3)	19.67	2.46
Electrics shock accidents	1 (0.1)	12 (0.1)	3 (0.03)	12.00	4.00

Aviation-related and railway-related accidents caused 49.5 and 43.3 deaths per incident, respectively (Table 4). The most lethal type of major work safety accident, with the highest death injury ratio was tailing dam accident. Machinery, collapse, electric shock accident and coalmine accident were specifically higher in death injury ratio, while aviation accident and railway accident were specifically higher in the number of deaths per incident (Fig. 3).

**Fig. 3:** Death per incident and death injury ratio in different types of accident

Discussion

Economic development is related to the incidence of accident. In developing countries such as China, increases in the growth rate of economic may have caused work safety accident rate to rise (9). In China, both major work safety accidents and deaths appear to have decreased since 2006, while the growth rate of GDP shows an increase steadily (varying in the range of 7.8% to 14.2%) (10). Efforts in regulations and surveillance, safety initiatives and innovations in safety controls by Chinese government can attribute to the decline. To improve the whole country's work safety, Chinese government has issued a series of supervision regulations especially for fatal serious work safety accidents, such as fire regulation, transportation regulation, coal mine and non-coal mine regulations, and the 11th Five-year Plan for National Economic and Social Development of the People's Republic of China (11). As part of this move, Chinese government has also strengthened the penalties for fatal major work safety. As the formulation and implementation of the regulations, provinces have made great improvements in preventing serious and major accidents.

The number of accidents and deaths show a sharp drop in ten years, which are broadly consistent with other published studies (12-17). While there has been a decline in the frequency of accidents and deaths in recent years, the mortality rate was still relatively high. According to Zhang et al. (12), the risk of death was 6.1 per million populations in work safety in whole country, which was higher than other countries (18).

Using hierarchical cluster analysis, we recognized that provinces of Hunan, Guizhou, Henan, Shanxi reported the highest number of major accidents and deaths, while provinces of Shanghai, Qinghai, Hainan, Ningxia, Beijing, Tianjin reported the least, which is consistent with the regional distribution of work safety accidents in whole country (12). After detailed analyzing, we found that Hunan, Guizhou, Henan and Shanxi had more than 55 major accidents, resulting in more than 900 deaths. Among these accidents, mining and trans-

portation contributed to the majority, accounting for more than 89% of all. These statistics may relate to the differences in natural environment, working conditions, the level of economic development and economic patterns.

More than 80% of major accidents occurred in transportation and mining. This percentage is comparable with the other published studies of work safety accidents in China (19, 20). Based on counts and proportions of accidents, transportation and mining that mostly produce casualties were still high-risk industrial safety accident types in China.

In transportation section, road traffic accidents contributed to the majority. Data analysis revealed that one major road traffic accident occurred every 10 days on average in China, while the average number of deaths in aviation was 49.5. This may be an important reason why fewer aviation accidents caused more widespread concern in the international community. Road Transportation Regulations of People's Republic of China was issued at the end of 2004 (21), and efforts were made to better disseminate the regulation, safety procedures, and tips to operators to increase drivers' awareness of risk and to improve emergency response capabilities. To reduce traffic accidents, some prevention strategies including driver training, working conditions, weather conditions, hours-of-service regulations, and safety culture should be better considered (22-25).

In mining section, coalmine accidents contributed to the majority. Literature reported that coal-mine accidents in China occurred ten times more frequently than that in India (1), and the death rate per million tons was 6.66 during the past 24 yr, which was ninety-four times more larger than in America (0.07) (26). The distribution and exploitation of mineral resources are an important factor for the significant difference between China and America. Fortunately, with the provisions on the prevention of coal mine accidents at the end of 2005 (27) and the closure of half of the operating mines in 2006, the death rate per million tons

showed a rapid decline since 2006 (26), and the number of mining accidents and deaths including major mining accidents declined. However, several safety concerns still persist in some mines, such as ignoring safety professionals, lack of emergency rescue measures and employee professional safety training. Some effective interventions are needed to mitigate the worst health and safety performance in China.

This study used death per incident and death injury ratio as a surrogate measure to describe the severity of major accidents and the urgency of emergency rescue. The declines in the number of death per service and mining accident indicated improvement on the special intervention. However, obstacles exist in transportation, construction and manufacturing intervention. As show in Fig. 4, the occurrence of tailing dam accident associated with major casualties and economic losses, and it will cause high case-fatality once occurred. Like tailing dam incident, collapse, machinery and electric shock accidents mostly resulted in higher proportion of death. Therefore, full risk assessment and prevention measures are the primary intervention to prevent these accidents. Aviation and railway accidents were recognized to result in relatively higher case-fatality and higher number of occupational injuries. Urgent emergency rescue are needed to reduce casualties and losses.

We discussed the major work safety accidents nationwide and the severity and emergency rescue urgency of accident using a scatter plot by death per accident and death injury ratio, the improvement compared with the similar studies (7, 12). Additionally, we searched the published literature and statistical yearbook to supplement the detailed information. This study had several limitations. The information registered in the SAWS system were not comprehensive, such as the cause of per incident, thus we could not do further analyze.

Conclusion

Ten years' work safety data indicate that the frequency of incidents and number of deaths of major work safety accidents were declined. Several

safety concerns persist in some segments. Targeted interventions and full risk assessment are urgently needed to improve this situation.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and /or submission, redundancy, etc) have been completely observed by the authors.

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