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Autopsy evaluation of coal mining deaths in the city of Zonguldak, Turkey

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Background: In this study, our aim was to evaluate the fatal occupational accidents that occurred in Zonguldak coal mines between the years 2005–2008.

Material/Methods: We retrospectively evaluated 42 fatal coal mine occupational accidents in Zonguldak (Turkey) between the years 2005–2008. The forensic records of autopsies referred to the chief prosecutors' office during 2005–2008 were reviewed retrospectively. There were 42 cases. The cases were evaluated with respect to age, mechanism of injury, body region of wound, cause of death, and legality of the mine.

Results: Ages of the deceased ranged between 17 and 52 (median: 32.9 yrs). Deaths were mostly in the 21–30 (35.8%), and 31–40 (30.9%) age groups. Only 1 case was younger than 18 years of age. Review of occupational fatalities has revealed that fatal accidents occurred mostly (76.2%) in the private, and fewer (23.8%) in the public mining enterprises. Crime scene investigation findings have demonstrated that of all occupational deaths (total n=42), 27 (64.3%) were due to subsidence, followed by methane gas poisoning (n=6, 14.2%), tram crash (n=3, 7.1%), log falls (n=2, 4.8%), electrocution (n=2, 4.8%), and methane explosion (n=2, 4.8%).

Conclusions: Despite laws and regulations concerning mining and because of problems in their implementation, Turkey leads the world in work-related accidents, occupational injuries, and deaths. Evaluation of autopsy findings of deaths in fatal occupational accidents occurring in coal mines is quite important in planning to decrease rates of occupational fatalities.

Keywords: Coal Mine • Autopsy • Forensic Medicine • Work Place • Death • Prevention

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Background

The richest hard coal reserves in Turkey are in Zonguldak City, which is located in the western Black Sea region. The city had a population of 106729 in 2008 and 105364 according to the 2011 census.

Nowadays, 26% of the global energy requirement is provided from coal mines. The greatest coal producer countries are China, USA, India, and Australia. Turkey possesses 0.2% of global coal reserves, ranks 4th among 35 countries in lignite production, and is 44th among 50 countries in hard coal production [1].

Because of its rich hard coal reserves, Zonguldak plays a prominent role in the mining industry. Mining is considered to be a very challenging industry in Turkey and in the world. According to the Statement in the Circular about Hazardous Conditions concerning Occupational Health, and Safety in the Workplace issued by the Ministry of Labor and Social Security, mining is classified in the "very hazardous category" [2,3]. Mining is one of the industrial enterprises in which most of the work-related accidents and occupational diseases are observed. Many workers are injured or died from mining accidents [2-4].

In deaths not related to natural causes (i.e., from mining accidents), determination of the cause of death is important for implementation of criminal and legal sanctions. In deaths related to occupational accidents, the people responsible for the accident are imprisoned, and family of the deceased can be entitled to receive material and moral compensation by civil courts because of deprivation of their rights. Therefore, to determine the mechanism and cause of death, on-site investigation and necropsy examinations of the deceased have utmost importance [5].

In this study, our aim was to evaluate the fatal occupational accidents that occurred in Zonguldak coal mines during the period of 2005-2008.

Material and Methods

The forensic records of autopsies referred to the chief prosecutors' office during 2005-2008 were reviewed retrospectively. There were 42 cases. The cases were evaluated with respect to age, mechanism of injury, body region of wound, cause of death, and legality of the mine.

In Turkey, autopsies are performed in compliance with the 86th to 89th articles of the Turkish penal code. Autopsy examinations are performed by a forensic medicine specialist in the presence of a public prosecutor. The procedure starts with the identification of the deceased. Afterwards, external visible findings

of the dead person are recorded, and then autopsy examination is performed to assess the cause and time of the fatal event. Based on the present state of the case, samples can be retrieved from the cadavers for histopathologic, biochemical, biologic, and/or criminal investigations. All data are gathered into a single report.

Results

Forty-two miners died in coal mines in the Zonguldak region between the years of 2005 and 2008. Ages of the deceased ranged between 17 and 52 (median: 32.9 years). Deaths were mostly in the 21-30 (35.8%), and 31-40 (30.9%) age groups. Only 1 case was younger than 18 years of age.

Review of occupational fatalities revealed that fatal accidents occurred mostly (76.2%) in the private, and fewer (23.8%) in the public mining enterprises. Crime scene investigation findings have demonstrated that of occupational deaths (total n=42), 27 (64.3%) were due to subsidence, followed by methane gas poisoning (n=6, 14.2%), tram crash (n=3, 7.1%), log falls (n=2, 4.8%), electrocution (n=2, 4.8%), and methane explosion (n=2, 4.8%).

Most (n=37, 88.1%) of the deaths occurred in mine caves, while 4 cases (9.5%) died in the hospital and 1 case (2.4%) died in an ambulance on the way to the hospital. All the cases were autopsied. According to the results of the autopsies, causes of death were mechanical asphyxia because of compression on the thoracoabdominal region (n=18, 42.9%), cerebral damage secondary to blunt head trauma (n=11, 26.2%), methane gas poisoning (n=6, 14.3%), blunt abdominal trauma, hepatic fragmentation, internal organ bleeding (n=4, 9.5%), and various other mechanisms (n= 3, 7.2%) (Table 1).

Discussion

The mining industry has the highest incidence of occupational deaths among all industries. Common causes of occupational deaths include rock falls, fires, explosions, methane intoxication, and electrocution [6].

While occupational mortality rates decreased in developed countries, incidence rates remain at high levels in developing countries like Turkey [7] (Table 2).

Beaumont stated that across all industries and countries, smaller enterprises tend to have higher accident rates than the larger ones [8]. Bigger firm size may be related to greater organizational safety because of the greater resources possessed by larger firms, the tendency of larger firms to have specialists in

Table 1. Etiopathogenesis, place, and type of the death event, and age of the miners who died at work.

Demographic characteristics	Legal		Illegal		Total	
	n	%	n	%	n	%
Age (yrs)						
≤20	1	25.0	3	75.0	4	9.5
21–40	6	21.4	22	78.6	28	66.7
≥41	3	30.0	7	70.0	10	23.8
Cause of death						
Mechanical asphyxia due to external thoracoabdominal compression	5	27.8	13	72.2	18	42.9
Cerebral damage, and bleeding secondary to blunt head trauma	3	27.3	8	72.7	11	26.2
Methane poisoning	1	16.7	5	83.3	6	14.3
Liver damage, and visceral bleeding due to blunt abdominal trauma	1	25.0	3	75.0	4	9.5
Other	0	0.0	3	100.0	3	7.2
Place of the death						
Mine cave	8	21.6	29	78.4	37	88.1
Hospital	2	50.0	2	50.0	4	9.5
Ambulance	0	0.0	1	100.0	1	2.4
Causes of the death event						
Subsidence	9	33.3	18	66.7	27	64.2
Methane poisoning	1	16.7	5	83.3	6	14.3
Tram clash	0	0.0	3	100.0	3	7.2
Other	0	0.0	6	100.0	6	14.3

Table 2. Employment status in the coal mining industry expressed as number of workers (%).

Year	Public		Private		Total (n)
	n	(%)	n	(%)	
1995	15.261	(59.5)	10.367	(40.5)	25.628
2004	18.248	(47.4)	20.244	(52.69)	38.492
2008	15.051	(30.4)	38.492	(69.69)	49.487

various fields, and higher compliance rates of larger enterprises to relevant regulations and laws. In another study, a negative correlation between the size of the parent organization and accident rates in the affiliated mines was detected [9].

In our study, the total number of deaths in private hard coal enterprises was found to be higher when compared with the governmental institution [Turkish Hard Coal Enterprise (TTK)] between the years of 2000 and 2008.

When employment status in the Turkish coal mining industry between the years 1995 and 2008 is evaluated, the gradual decrease of employment rates in the public sector and increase in the private sector are noteworthy [7] (Table 3).

The number of deaths per million tons of coal mined was 57 times higher in private enterprises in 2003 and 2 times higher in 2006 when compared with public industry (TTK) (Table 4).

Table 3. Number of deaths per million tons of coal mined in TTK, and Turkish private coal enterprises.

Years	TTK	Private coal mine industry
2000	3.98	59.25
2001	2.12	94.82
2002	3.56	80.38
2003	3.98	229.44
2004	2.66	76.78
2005	6.00	3.91
2006	1.97	3.77
2007	2.98	18.36
2008	4.41	11.50

Although the number of deaths per million tons of coal produced is higher in the private sector, mortality rates have decreased since 2004. In 2005, mortality rates in the TTK were nearly 1.5 times higher than those in the private sector.

Worldwide, national coal mining industries are increasingly being privatized and developing countries have opened up their mineral resources to the private sector.

Private mines (mostly informal) employ the poorest people toiling at the lowest wages in the worst security, health, and safety conditions. The outstanding feature in this definition is scale: small production, small capital investment, labor intensiveness, shallow mineral deposits, and low technology deployment.

Jin et al. conducted a study to examine the characteristics of work-related fatalities in the People's Republic of China (PRC) available from the State Work Accident Briefing (SWAB) system from April 2001 to March 2003. The findings were compared with a previously published regional work fatality study in China, data from the U.S. Census of Fatal Occupational Injuries, and estimates from the International Labor Organization (ILO). During the 2-year period, 1538 work-related events (7046 worker fatalities) were recorded. Generally, regions with lower economic activity reported more fatalities [10].

The U.S. Centers for Disease Control and Prevention (CDC) report published in 2001 indicated a general decrease during 1980–1997 in the annual number of deaths and the annual rates of occupational deaths in the United States. In addition, the leading causes of death have changed through the 1990s. Although surveillance data cannot identify reasons for these temporal trends, changes in the workplace (e.g., increased and better targeted regulations, improved hazard awareness, new

technology, and mechanization) are possible factors. In addition, changes in the economy, the industrial mix, and the distribution of the workforce, and improvements in acute trauma care for injured workers may have contributed to these decreases [11].

Skowronek et al., retrospectively examined autopsy reports of coal miners who died after coal mine accidents, and emphasized the importance of determination of the cause, the mechanism of the death event, and identity of individuals in mass death events. They stated that mutual cooperation of experts from various fields is the basis for executing appropriate procedures after a traumatic death in the coal mine [12].

Attfield et al., in their longitudinal observational study that evaluated death rates in miners for 23 years, detected elevated mortality from nonviolent causes, non-malignant respiratory disease (NMRD), and accidents, but found that lung cancer and stomach cancer mortality rates were not elevated [13].

Chowaniec et al. evaluated the cause and mechanisms of death of 6 miners in a coal mine accident in 1998, based on the outcomes of crime scene investigations, medical documents, autopsy reports, and chemical and histopathologic examinations, and concluded that the deaths were associated with anoxia secondary to acute respiratory failure [14].

In Turkey, as stated in the code of criminal procedures related to forensic cases, identification of the deceased is a priority. Afterwards, determination of the cause and mechanism of death is attempted [5].

In our cases, fatal injuries were mainly related to subsidence, followed by methane gas leakage, tram collision, and other causes.

We have investigated causes and mechanisms of death in our cases, and found that nearly half of the deaths (n=18, 42.9%) were related to mechanical asphyxia due to external thoracoabdominal compression, followed by head trauma (n=11, 26.2%), methane poisoning (n=6, 14.3%), hepatic damage, and internal organ bleeding secondary to abdominal trauma (n=4, 9.5%), and other causes (n=3, 7.2%).

Methane explosions in various affiliated coal mines of the Turkish Hard Coal Enterprises caused a number of deaths in 1983 (Zonguldak Armutçuk, n=103), 1992 (Zonguldak Kozlu Incir Harman, n=262), 1993 (Zonguldak, Karadon, n=65), and on May 17, 2010 (Zonguldak, Karadon, n=30). There were 8 coal mine deaths in an accident in a coal mine operated by a subcontractor under the auspices of the Kozlu Directorate of the TTK on January 7, 2013.

Table 4. Fatal occupational accidents in mining sectors in Europe (1/100.000).

Countries	2004	2005	2006	Median (3 years)
Austria	23.00	15.40	7.90	15.43
Bulgaria	23.90	30.00	25.80	26.57
Croatia	19.10	38.10	19.20	25.47
Czech Republic	41.70	13.60	7.80	21.03
Estonia	0.00	17.00	38.50	18.50
Finland	0.00	43.50	0.00	14.50
France		11.20	19.20	15.20
Hungary	0.00	6.71	0.00	2.24
Ireland	1.00	4.20	2.10	2.43
Italy	19.00	10.00	22.00	17.00
Lithuania	0.00	0.00	35.50	11.83
Letonia	65.10	31.40	0.00	32.17
Malta	0.00	0.00	0.00	0.00
Moldovia	43.40	36.90	0.00	26.77
Norway	9.10	3.00	0.00	4.03
Polonia	33.60	19.00	15.80	22.80
Portugal	82.50	31.40	17.10	43.67
Romania	18.00	16.00	19.00	17.67
Slovakia	34.00	0.00	65.00	33.00
Slovenia	0.00	0.00	26.00	8.67
Spain	40.20	32.00	38.40	36.87
Sweedeen	0.00	0.00	13.30	4.43
Switzerland	2.20	1.50	1.70	1.80
Turkey	78.70	124.50	74.20	92.47
United Kingdom	3.50	8.80	15.40	9.23
Average				20.15

Although our study investigated deaths due to fatal mining accidents in Zonguldak city between 2005 and 2008, no mass death events occurred during that time interval.

Apart from equipment, age, longer work hours (part of a drive for greater worker productivity), and sleep deficits (which might be expected in hot locations) are related with the physical and mental preparation for paying attention. Poor conditions such as uneven floors, slippery surfaces, narrow, cramped, or otherwise inadequate access, and poor lighting can be factors leading to fatal accidents. These concerns, naturally, cannot

be expected from illegal mining operations, as is seen from the high death rates in Table 1.

In Turkey, entrepreneurs who want to operate a mining enterprise must comply with legal requirements when employing workers, encompassing the regulations as “Number of the Construction of Mines, Quarries, and Tunnels, and Relevant Occupational Safety Measures”, “Necessary Measures to be Taken in Potentially Flammable and Explosive Mines,” and “Occupational Health and Safety Measures to be Taken in the Underground and Surface Mining Enterprises”.

Although occupational accidents have increased in recent years, there is a decrease in occupational deaths and injuries. Evaluation of autopsy findings of fatal occupational accidents in coal mines is very important to formulate a strategy to decrease occupational deaths in the mining sector.

Most of the accidents arise from preventable problems, which emphasizes the necessity of effective implementation of audits. Accordingly, assessment of risks from the ergonomic point of view should be monitored constantly by experts. Surveys on work-related accidental fatalities should be also taken into consideration to formulate a strategy for the prevention of occupational deaths in the mining sector.

Privatization, subcontracting, and leasing procedures implemented since the early 1980s have narrowed the operational field of public mining enterprises like TTK; private industries that disregard well-being, health, and safety of their employees prefer a cheap workforce and prevent organization of their workers into labor unions have become prominent providers in the coal mining sector.

Boal estimated the effect of unionization on accident fatalities using 2 data sets on early twentieth century coal mining – a state-level data set and a mine-level data set. In both data sets, unionization was estimated to have reduced fatalities by about 40%. The unionization effect persists after controlling

for state safety regulations, apparently supporting union president John Mitchell's claim that union miners supported each other in refusing to work in unsafe places [15].

Conclusions

In Turkey, like other undeveloped countries, unionism is not as free as in developed countries. Unionism is necessary in democratic countries. Subcontractor firms are invading coal mining sectors rapidly in our country. As inadequate small subcontractor firms increase, deaths per million tons of coal mined also increase. As Beaumont stated, larger firm size may be related to higher organizational safety because of the greater resources possessed by larger firms, the tendency of larger firms to have specialists in various fields, and higher compliance rates of larger enterprises to relevant regulations and laws.

We believe that as true democracy, which protects the weak and poor, develops in a country, unionism and worker rights can achieve the standards of developed democratic Western nations. This can reduce preventable deaths.

In conclusion, because of the difficulties encountered in the implementation of legal procedures, Turkey is among the countries with high incidence of occupational accidents, injuries, and deaths.

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