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FATAL ACCIDENTS AT WORK IN AGRICULTURE ASSOCIATED WITH ALCOHOL INTOXICATION IN LOWER SILESIA IN POLAND

ŚMIERTELNE WYPADKI PRZY PRACY W ROLNICTWIE NA DOLNYM ŚLĄSKU W POLSCE ZWIĄZANE Z UPOJENIEM ALKOHOLOWYM

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ABSTRACT

Background: Determining the prevalence of alcohol intoxication and the level of intoxication in victims of fatal occupational accidents is necessary to improve work safety. The circumstances of the accident and the time between alcohol consumption and death are important factors. **Material and Methods:** A retrospective review of 18 935 medico-legal autopsy reports and toxicological reports performed in the Department of Forensic Medicine at the Wrocław Medical University, Poland, in the years 1991–2014. The study protocol included circumstances, time and cause of death, injuries, quantitative testing for the presence of ethyl alcohol, gender and age. **Results:** There were 98 farm-related fatalities. There were 41.8% (N = 41) of victims who had been intoxicated – 95.1% (N = 39) of them were males aged 19–70 years old, 4.9% (N = 2) were females aged 37–65 years old. In 8 cases the blood alcohol concentration (BAC) was 50–150 mg/dl; in 15 cases it was 150–250 mg/dl and in 18 cases it was > 250 mg/dl. In 21 cases, the BAC was determined using alternative material and 76% (N = 16) victims were in the alcohol elimination phase with 19% (N = 4) victims in the alcohol absorption phase. The most common causes of death were traffic accidents, drowning and deaths resulting from being caught in or hit by moving parts of machinery or equipment. **Conclusions:** Alcohol consumption is a crucial risk factor in fatal agricultural accidents. In order to establish the time of alcohol consumption, all victims of agricultural accidents should be tested for alcohol concentration in their blood and urine or vitreous. Improving safety at work requires that the sobriety of employees should be monitored before and during work. Med Pr 2017;68(1):23–30

Key words: alcohol, agriculture, occupational injuries, blood alcohol concentration, forensic toxicology, work-related deaths

STRESZCZENIE

Wstęp: W celu poprawy poziomu bezpieczeństwa pracy w rolnictwie konieczne są gromadzenie i analiza danych dotyczących liczby osób w stanie nietrzeźwości, które ulegają śmiertelnym wypadkom, poziomu alkoholu w ich organizmie, okoliczności śmierci i czasu między konsumpcją alkoholu a zgonem. **Materiał i metody:** Przeprowadzono retrospektywną analizę wyników 18 935 sądowo-lekarskich sekcji zwłok i raportów toksykologicznych wykonanych w Katedrze Medycyny Sądowej na Uniwersytecie Medycznym we Wrocławiu w latach 1991–2014. Protokół badania obejmował okoliczności, czas i przyczynę zgonu, obrażenia, wynik badania ilościowego na zawartość alkoholu, płeć i wiek badanych. **Wyniki:** Stwierdzono 98 wypadków śmiertelnych przy pracy w rolnictwie. Pod wpływem alkoholu było 41,8% (N = 41) ofiar wypadków, w tym 95,1% (N = 39) mężczyzn w wieku 19–70 lat i 4,9% (N = 2) kobiet w wieku 37–65 lat. W przypadku 8 osób stężenie alkoholu we krwi wynosiło 0,5–1,5‰, u 15 osób – 1,5–2,5‰, a u 18 osób – powyżej 2,5‰. U 21 ofiar wypadków poziom alkoholu oznaczono w materiale alternatywnym i ustalono, że 76% (N = 16) z nich znajdowało się w fazie eliminacji alkoholu z organizmu, a 19% (N = 4) w fazie wchłaniania. Najczęstszymi okolicznościami śmierci były wypadki drogowe, utonięcia i urazy związane z pochwyceniem lub uderzeniem przez poruszające się elementy maszyn rolniczych. **Wnioski:** Spożycie alkoholu jest istotnym czynnikiem ryzyka śmiertelnych wypadków w rolnictwie. W celu ustalenia czasu konsumpcji alkoholu przez ofiary wypadków należy oznaczać u nich stężenie alkoholu we krwi i w moczu lub szkliste. Poprawa bezpieczeństwa w miejscu pracy wymaga monitorowania trzeźwości pracowników zarówno przed rozpoczęciem pracy, jak i w jej trakcie. Med. Pr. 2017;68(1):23–30

Słowa kluczowe: alkohol, rolnictwo, wypadki przy pracy, stężenie alkoholu we krwi, toksykologia sądowa, zgony związane z pracą

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INTRODUCTION

Agriculture ranks among the most dangerous occupations. In Europe, the fatal work-related accident incidence rate in agriculture in 2008 was 19.1 per 100 000 workers [1]. According to the statistics from the Polish Central Statistical Office (Główny Urząd Statystyczny – GUS), in 2013 the total accident rate equaled 10.85 per 1000 farm workers and the rate of fatal accidents was 0.101 per 1000 farm workers. Those indicators were much lower in other industries (excluding agriculture): the accident rate of 7.55 per 1000 employees and only 0.024 fatal accidents [2]. Apart from many other factors, the human factor still remains the most important risk factor for occupational accidents [3,4].

The specificity of agricultural professions is that employees are often deprived of adequate supervision, work is carried out independently (no cross-checking), people work in different types of private farms which are often run by owners, family or friends who lack adequate training (relating to health and safety rules), personal protection equipment is not used and no health checks are performed by occupational physicians. The influence of work safety institutions is limited outside bigger farms and the independent nature of the work results in a lack of discipline and workers fail to comply with safety rules, including those forbidding excessive alcohol consumption. It is a well-known fact that one of the major human risk factors at work is alcohol consumption, which is particularly evident in agriculture [5–11].

Many researchers have assessed the scale of this phenomenon based on demographic differences and on the nature of the work by providing detailed epidemiological data [6,7,12–15]. Studies indicate that although many systemic solutions have been introduced (e.g., installation of breathalyzers in agricultural machinery to prevent operation by intoxicated workers), the problem still exists and accidents related to alcohol abuse (including death) pose a serious threat to safety.

The aim of this study has been to retrospectively analyze the incidence of intoxication and the degree of intoxication in fatal farm-related accidents in the Lower Silesia, Poland, taking the circumstances of the incidents and the time between alcohol consumption and death into account.

MATERIAL AND METHODS

A retrospective review of 18 935 medico-legal autopsy reports and toxicological reports established by the

Department of Forensic Medicine in Wrocław, Poland, was conducted by the authors in the years 1991–2014 which included 98 fatal farm-related incidents. The victims came from the Lower Silesia, i.e., a big, typical, demographic region in south-west Poland. All deaths occurred in agricultural circumstances, few were connected with forestry and fishing but inside agricultural farms.

The definition of fatal agricultural death and any unwitting injury resulting in death and occurring during the activity related to work on the farm or in connection with the performance of such activities or off-site as a part of normal farm activities related to agricultural activity must be consistent with the definition given by the International Labor Organization [16] and the European Agency for Safety and Health at Work (EU-OSHA) [17].

The data from forensic reports included circumstances, time and cause of death, morphological descriptions of injuries, quantitative toxicological blood tests for alcohol levels in all cases and in 21 cases tests using alternative material, i.e., urine or vitreous. The authors used the headspace gas chromatography with a flame ionization detector (HS-GC with FID, Agilent, USA) to analyze alcohol concentration in accordance with standard forensic toxicology procedures. However, due to the uncertainty of the method used and variations in alcohol concentration in the plateau phase, it was assumed that differences in the blood and alternative material > 10 mg/dl allow for the differentiation of the alcoholemia phase at the time of death: absorption or excretion phase which implicitly allows us to determine the approximate time of alcohol consumption before death. It was assumed that the absorption phase, depending on the type of alcohol consumed and the distribution of alcohol consumption over time, may last 30–90 min.

The study protocol included gender, age, date, causes and circumstances of death as well as the ethyl alcohol concentration. According to the provisions of the Polish wheeled traffic and labor law it was assumed that the blood alcohol concentration (BAC) > 50 mg/dl equates to intoxication. Degrees of intoxication were evaluated with respect to the BAC as follows:

- 50–150 mg/dl – mild intoxication,
- 150–250 mg/dl – average,
- > 250 mg/dl – significant.

The authors excluded cases in which the nature of the material taken, the condition of the body and the

results of the analysis could indicate the presence of endogenous alcohol. The study did not include deaths occurring in hospital > 24 h after an injury due to inadequate toxicological data related to the accident. We also excluded deaths resulting from diseases regardless of their relationships to the victims' work. Circumstances of death were divided into the following categories: traffic accidents, death caused by machinery or equipment, fire, electrocution, intoxication, death caused by animals, drowning, falling from height, crushing, burial, environmental factors (including hypothermia).

RESULTS

A total of 98 farm-related fatalities were identified between 1991–2014. At the time of the fatal accident 41 (41.8%) out of 98 victims were intoxicated and 39 (95.1%) out of 41 persons were males aged 19–70 years old (< 20 years old (N = 1), 20–29 years old (N = 3), 30–39 years old (N = 13), 40–49 years old (N = 10), 50–59 years old (N = 9), > 60 years old (N = 3)), 2/41 were females aged 37–65 years old. In the whole group liver steatosis was only reported in 2 cases and liver cirrhosis – in just 1 case. In 18/41 (43.9%) of cases, blood tests for the concentration of ethyl alcohol revealed significant intoxication (> 250 mg/dl), out of which as many as 11/18 cases were in the age group of 30–39 years old (Table 1).

The highest blood alcohol concentration was 520 mg/dl and the cause of death of a 47-year-old man was ethyl alcohol poisoning. The man died while logging in the forest. The next 2 highest results – 460 mg/dl and 370 mg/dl – were related to traffic accidents, i.e., the first person fell from a tractor's cabin and was run over by the trailer, and the second person fell from the cabin and was crushed by the tractor which had rolled over and fallen into a ditch. The victim of the first accident was a 40-year-old male who had suffered multiple-organ damage whereas the second accident involved a 39-year-old male who had died of suffocation as a result of rapid chest immobilization. In both cases the nature of the injuries indicated that they had occurred during life pointing to traumatic death rather than lethal intoxication. In total, ethyl alcohol intoxication was found to be the sole cause of death in 3 cases.

There were only 2 women in the group of intoxicated victims. The first, a 37-year-old, died of hypothermia and her BAC was 70 mg/dl. The second, a 65-year-old, drowned in a water tank located on the farm and her BAC was 220 mg/dl. Out of the 41 positive BAC cases, in 21 cases alcohol concentration was determined using alternative material (urine or vitreous) to obtain a significant (> 10 mg/dl) difference in 20 cases as compared to the blood tests. In 1 case, comparable concentrations of alcohol in blood and urine indicated a phase of leveled concentrations. In 16/21 (76%) cases, at the time of death victims were in the alcohol eli-

Table 1. Age and blood alcohol concentration of the victims in fatal farm-related incidents in Lower Silesia in Poland, 1991–2014
Tabela 1. Wiek i stężenie alkoholu we krwi ofiar śmiertelnych wypadków przy pracy w rolnictwie na Dolnym Śląsku w Polsce w latach 1991–2014

Age [years] Wiek [w latach]	Fatalities with blood alcohol concentration Ofiary śmiertelne z różnym stężeniem alkoholu we krwi [n]				total ogółem
	intoxicated w stanie nietrzeźwości			total ogółem	
	50–150 mg/dl 0,5–1,5 ‰	150–250 mg/dl 1,5–2,5 ‰	> 250 mg/dl > 2,5 ‰		
< 20	0	1*	0	1	2
20–29	1*	2*	0	3	6
30–39	1**	2*	11*	14	24
40–49	2*	4*	4*	10	23
50–59	4*	4*	1*	9	24
≥ 60	0	1*, 1**	2*	4	19
Total / Ogółem	8	15	18	41	98

* Males / Mężczyźni.

** Females / Kobiety.

mination phase, and in 4/21 (19%) cases they were in the alcohol absorption phase. Out of 20 traffic accidents and accidents involving machinery, the results allow the alcoholemia phase to be determined in 12 cases, out of which 11 victims were in the elimination phase.

The most common (16/41) cause of death in victims with proven alcohol intoxication was a traffic accident, i.e., being run over or hit by a moving vehicle (a tractor, a trailer, a combine-harvester, a water cart, a drill, a horse-drawn carriage). The next most common cause of death (in 5 cases) was drowning. The third (in 4 cases) most common cause of farm-related death was being caught or hit by moving parts of machinery or equipment (Table 2).

The most common injury found during the autopsies (regardless of the cause of death and alcohol intoxication) was multiple organ damage (48/98). Twenty-two out of 48 victims in this group were intoxicated, with 10 being significantly intoxicated. In the group of intoxicated victims (41/98) the second most frequent type of injury was chest injury (9/41), which occurred

following traffic accidents, accidents with machinery, burials and crushing. During these accidents, the most common cause of death was blunt chest trauma with immobilization and inability to breathe. At the same time, chest injuries occurred in 17/98 cases of agriculture accidents during this period (regardless of alcohol intoxication). In 8/98 cases the autopsy revealed lethal isolated craniocerebral injuries with 2 people intoxicated. Forty-one out of the 98 accidents (41.8%) occurred during the intensive fieldwork season (between May and November). Almost half (19/41) of the cases of intoxication occurred during this period.

DISCUSSION

The authors draw our attention to the high percentage rate of intoxicated agricultural workers (> 41%) who had fatal occupational accidents and the large number of farmers significantly intoxicated (with the BAC > 250 mg/dl in 43.9% of all the cases examined). Although observations made by other investigators also

Table 2. Circumstances of fatal farm-related incidents and blood alcohol concentration of the victims in Lower Silesia in Poland, 1991–2014

Tabela 2. Okoliczności śmiertelnych wypadków przy pracy w rolnictwie a stężenie alkoholu we krwi ofiar na Dolnym Śląsku w Polsce w latach 1991–2014

Death circumstances Okoliczności śmierci	Fatalities with blood alcohol concentration Ofiary śmiertelne z różnym stężeniem alkoholu we krwi [n]				total ogółem
	intoxicated w stanie nietrzeźwości			total ogółem	
	50–150 mg/dl 0,5–1,5 ‰	150–250 mg/dl 1,5–2,5 ‰	> 250 mg/dl > 2,5 ‰		
Traffic accident / Wypadek drogowy	1	5	10	16	32
Being caught in or hit by moving parts of agricultural machinery or equipment / Pochwycenie/uderzenie przez poruszające się elementy maszyn rolniczych	3	1	0	4	15
Fire / Pożar	0	1	1	2	4
Electrocution / Porażenie prądem	0	0	0	0	2
Animals / Zwierzęta	0	2	1	3	5
Drowning / Utonięcie	0	3	2	5	9
Falling from height / Upadek z wysokości	0	1	0	1	3
Crushing / Przygniecenie	3	1	1	5	17
Environmental factors / Czynniki środowiskowe	1	1	0	2	5
Alcohol intoxication (as the only known circumstance) / Zatrucie alkoholem (jako jedyna znana okoliczność)	0	0	3	3	3
Other intoxication (as the only known circumstance) / Inne zatrucie (jako jedyna znana okoliczność)	0	0	0	0	3
Total / Ogółem	8	15	18	41	98

indicate alcohol as a risk factor in accidents, the percentage rate of intoxicated workers was not as high. In addition, these indicators are clearly lower in developed countries. In an Australian study, authors reported blood alcohol readings > 50 mg/dl in only 20.7% of victims of fatal agricultural accidents in the age group of 15–24 years old, and in 11.9% of victims in the age group ≥ 55 years old [18]. McNeilly reported that in the State of Victoria (Australia), the positive BAC was only reported in 7% of all agricultural accidents in the years 2001–2006 [19]. A similar American study (Texas, Harris County) of agricultural accident victims reported intoxication in 13.3% [5].

In addition, in the studies which analyzed all work-related accidents, regardless of the industry, the number of intoxicated victims was much lower than in our study. In Jordan this rate was 9.1% among 88 victims of all work-related accidents subjected to autopsies between 2008–2012 [11]. Similar values, i.e., 11%, were reported following the examination of victims of occupational accidents in another American report from North Carolina [20].

The aforementioned studies were conducted in countries which are demographically, culturally and economically different from Poland, which may have also influenced the results obtained. A lower percentage rate of people intoxicated, although not as low as in the works cited, was also reported in the Serbian study where deaths occurring between 1996–2008 were examined (Serbia's economic and demographic structure is similar to that in Poland). Out of 337 cases of work-related fatal accidents (not just in agriculture), the victims of which were subjected to blood alcohol content test, the BAC > 50 mg/dl was found in 24% of cases, mostly in men, and in the majority of results it did not exceed 150 mg/dl [8]. Some authors of those reports clearly indicate that blood alcohol content tests were not carried out in all the analyzed cases.

One of the factors which should be considered when interpreting the results obtained is varied alcohol consumption per capita depending on the size of the country. This indicator is higher in Poland than the European and North American average but not high enough to fully explain the scale of such divergences [21]. As there is no scientific publications from Poland, our results can't be compared to other data on intoxication in fatal work-related accidents in Poland. What is consistent in all similar studies is that substantially more men than women drink alcohol at work [2,4,22,23], which is also consistent with the

data on worldwide alcohol consumption according to gender [21]. In our study, this ratio equaled 39:2 and resulted mainly from the nature of the agricultural work where difficult, physical and risky tasks are performed by men.

The relationship between the BAC values and the circumstances of accidents at work and injuries suffered was examined by Foster and Dissanaike [10]. In 2007–2011, 504 Trauma Center patients who sustained work-related injuries were tested for the BAC upon admission – 4.5% of them were blood alcohol concentration positive (according to the legal BAC limits in Texas which equaled 80 mg/dl). A significant positive correlation between the degree of intoxication and the severity of injuries was reported especially on farms, which accounted for as many as 48.6% of all serious injuries where the positive BAC was observed. This is consistent with the results of our study in which a large number of the highest BAC values (> 250 mg/dl) was observed in traffic accidents (62.5% of all the positive BAC cases related to traffic accidents) and polytrauma (48/98 agricultural fatalities with multiple organ damage, out of which 22 had the positive BAC and 10 had the BAC > 250 mg/dl). This proves that there is a greater likelihood of severe, fatal injuries when the BAC is high and a higher accident rate when operating vehicles.

The issue of traffic accidents involving intoxicated agricultural workers is significant when it comes to the type of vehicles used [2,4,22,23] drew attention to the particularly dangerous accidents involving tractors, i.e., tractors rolling over, the victim being run over, crushed or pinned down by the tractor [22]. Similar information is provided by the Centers for Disease Control and Prevention (CDC) databases [23]. Our observations are in line with the latter as, out of 32 traffic accidents, 20 involved tractors, 9/20 were crushings by an overturned tractor and 11/20 involved falling out of the cabin. Tractors are dangerous vehicles because their centre of gravity is high and their track width is relatively narrow, which makes them prone to tipping over. Some older tractors have unprotected cabins and cabin doors are left open during work, there are too many people inside, especially on the way to or from work, and all this results in people falling out of the cabin [24–26].

In our study group, almost a half of traffic accident victims were intoxicated (16/32), including 4/11 of those who fell from the tractor. The main way of reducing the number of accidents is the removal of the so-called

“dangerous tractors” from widespread use [24,26,27]. Modern tractors have in-vehicle breathalyzers (breath alcohol ignition interlock device – BAIID) which prevent operation by intoxicated workers. They also have air-conditioned cabins with seatbelts and wide-wheel track systems and vehicles equipped with a roll-over protective structure (ROPS) are much safer [25,27] both for intoxicated and sober operators. However, the high cost may hinder their sale. According to our results, a large group of fatal accidents involved incidents with dynamic machinery other than vehicles (15/98 of all accidents out of which 4/15 victims had the positive BAC). The circumstances of the deaths were mainly related to being caught or hit by moving parts of machines or being crushed, which could be connected to the fact that alcohol hinders psychophysical abilities.

One objective of this work, in addition to establishing the prevalence of intoxication among victims of fatal accidents in agriculture, was to analyze the time between alcohol consumption and carrying out risky jobs and, finally, between alcohol consumption and fatal accidents. The link between alcohol consumption and the risk of accidents has already been discussed by some researchers. None of them, however, has objectively estimated the time of alcohol consumption.

Wang et al. reported that a lower incidence of accidents occurred in patients who consumed alcohol before taking up work, which is not consistent with a similar Indian study [7,28]. Toxicological data obtained from the examination of 2 types of biological material for the presence of ethyl alcohol, i.e., either blood or urine or vitreous, additionally allowed us to analyze the time and the manner of alcohol consumption before death. Such information may be of paramount importance for creating systems prohibiting or excluding intoxicated workers from carrying out and performing work. Bearing in mind that work on a farm is often time-consuming, lasts all-day, often without supervision, and breaks may be taken at any time, it should be assumed that alcohol is not just consumed before work but also during breaks or at work. This situation significantly impedes the initiation of preventive actions and involves implementing a more complex control system.

The authors reported that an overwhelming number of victims (16 of 21) for whom the alcoholemia phase could be determined was in the elimination phase. Assuming that the alcohol consumption was extended

over some period of time, this meant that consumption had taken place at least 1 h before death. What is more, in the majority of cases in the elimination phase, the BAC was > 250 mg/dl and almost all the cases involved a traffic or machinery accident. The positive here is that if there is a period of time between alcohol consumption and the accident, appropriately designed and implemented supervisory systems designed to control the sobriety of workers could be used for signaling and averting dangers, in order to avoid tragedy. In the cases analyzed, the future victims were intoxicated even 1 h after alcohol consumption. Despite the fact that intoxication symptoms were obvious to them and to their colleagues, they began or continued with professional activities. This proves that intoxicated workers and their environment lacked critical assessment regarding the influence of alcohol on mental and physical condition; they were unaware of or even ignored the threats posed by alcohol.

The consideration of the alcohol consumption of agricultural workers in the context of the frequency of accidents comes down to 2 concepts: consumers' tolerance to alcohol [29] and the influence of alcohol on the frequency and fatal outcome of work-related accidents which, among other things, is evident in our results. In their questionnaire study of the agricultural population in the northern provinces of China, Wang et al. [7] found a positive correlation between the frequency of alcohol consumption, the amount consumed and past alcoholism with an increased number of accidents. Similarly, in a study conducted in Finland [29], where alcohol consumption per capita is similar to that found in Poland [21] it was reported that mortality rates were highest among people with the highest number of heavy drinking episodes. However, our study does not allow us to draw similar conclusions. It is surprising that in the 41 cases examined, alterations were only observed in 2, and they were presumably related to alcoholism, liver cirrhosis or liver steatosis.

This study also has several limitations. First of all, the material only concerns 1 demographic region and has been retrospectively collected by only 1 institution. The relatively limited number of cases and their diversity make it impossible to conduct a more detailed analysis than the one presented here as well as to draw more general conclusions. Moreover, alcohol concentrations in blood and in the alternative material were not determined at the same time in all cases, which could also have influenced the presented data.

CONCLUSIONS

Alcohol consumption is a crucial risk factor in fatal agricultural accidents, especially in those related to traffic accidents and the operation of machinery or equipment. Due to the fact that forensic autopsy reports are extremely detailed, they provide more accurate information than other medical records or analyses prepared by the occupational safety services. So as to determine the time of alcohol consumption, all victims of agricultural accidents should be tested for alcohol concentration in their blood and urine or vitreous. To increase safety at work, considering that the alcohol was consumed at various times at work (before and during work) breath alcohol concentration should be checked both before and during work. It should also be emphasized that intoxicated workers must not operate vehicles and agricultural machinery – it is therefore appropriate to promote BAIID solutions or even implement them as a legal requirement. Finally, there is a need to educate agricultural workers on the dangers posed by alcohol consumption.

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