Causal relationship occupation injury in the food industries

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ABSTRACT

Introduction. Analyzing causes of injury in the food industries give an opportunity to create reasonable and effective ways of prevention and decreasing risks of workers injuries. The purpose of work is to research cause-and-effect relationships that lead to injury in the food industry. The object of research is occurrence of the occupational injuries at the food industry enterprises for the period 2003...2012.

Material and methods. Methods of statistical analysis were used. Analysis was done on the basis of statistics of occupational injuries on the causes of accidents and the types of events in the food industries.

Results and discussion. Obtained risk matrices of the injuries with death or deathless consequences for 15 types of accidents that were causing to accidents, and 16 reasons of traumatism during 2003–12 period. There are quantitative statistical evaluations for 240 types of risk reasons for binary groups "the reason of an accident – type of traumatic effect" in the matrices of risk. This approach allows for the analysis of direct causal relationships that occur during getting injury and identify both basic and hidden cause of occupational injuries, as well as types of events that lead to accidents on the basis of a form of mandatory annual reporting. It is the first time the regularity of the ranking of binary ratio "the reason of an accident – type of traumatic effect" is set for enterprises of the food industry. And its main clue is that approximately 20% of them causes 75% of the traumatism risk. Results of research can be used in improving management decisions projects that can provide safe working conditions in the food industries.

Introduction

For effective health and safety management, selection and use of reliable and affordable measures and means of prevention of accidents in the food industry need to know how to identify direct and hidden causes of occupational injuries.

Only with the knowledge of these causes we can confidently identify ways of neutralization or reducing their influence for risk.

To the level of occupational injuries in the food industry affects a large number of factors, which act in the mutual connection and conditionality, which leads to accidents with severe consequences for the staff [1-3]. The organization and execution of tasks on the reduction of injuries, accident prevention, development of scientific and practical recommendations for the creation of safe working conditions for the production staff in the food industries is important and priority area of development of safety management [4].

These circumstances require solving scientific problems: improving the method of analysis of the causes of accidents that have occurred at food industry enterprises. *The purpose* is to research cause-and-effect relationships that lead to injury in the food industry.

The object of research is occurrence of the occupational injuries at the food industry enterprises for the period 2003...2012.

The subject of research is dependence of the influence of cause-effect relationships that leading to injury at the food industry enterprises.

Material and methods

A promising research method of statistics of occupational injuries - is the method of causal relationships. This method allows you to combine disparate statistics on the causes of accidents and the types of events that result in injury into a single system of quantitative estimates of different risks for pairs "cause - the kind of traumatic event". It specifies causal relationships laid down in the official statistics on occupational injuries, and more clearly and unambiguously indicates the measures and means to effective prevention of risks.

The main sources of official estimates for generalized causes of occupational injuries in Ukraine are the forms of state statistical reporting (№ 7-ТНВ) [5-6]. The above statistical reports allow you to select the 16 main causes of accidents and 15 types of traumatic events that traditionally analyze separately, independently one from the other. The causes of injury include: design flaws ($П_1$), imperfection of technological processes ($П_2$),unsatisfactory technical condition of production assets ($П_3$),other technical reasons ($П_4$), deficiencies in training ($П_5$), violation of work and rest ($П_6$), deficiencies of medical examination (professional selection) ($П_7$), the absence or non-use of personal protective equipment ($П_8$), breach of technological process ($П_9$), violations in the operation with industrial funds ($П_{10}$), traffic violations ($П_{11}$), violation of labor and production discipline ($П_{12}$), other organizational reasons ($П_{13}$), alcohol and drug intoxication ($П_{14}$), and other physiological reasons ($П_{15}$), other reasons ($П_{16}$).Statistical information about the types of events that led to the injury of the employee includes the following events: traffic accidents (B_1), falling down (without falling from a height) (B_2), falling down from a height (B_3), falling objects, materials, rocks, soil (B_4), the accident with moving, flying, rotating parts (B_5), electric shock (B_6), the action of harmful and toxic substances (B_7), the effect of ionizing radiation (B_8), neuro-psychological overload (B_9), contact with animals, insects, other (B_{10}), drowning (B_{11}) deliberate killing or intentional acts of another person, which led to injury (B_{12}), natural disaster (B_{13}), fire (B_{14}), and other events (B_{15}).

Results and discussions

Definition of matrix risks is proposed to perform by calculating the generalized statistics using the formula [7]:

$$\Pi_i B_j = \frac{B_j^t \times \Pi_i^t}{\sum_{i=1}^{n} \Pi_i^t},$$

$\Pi_i B_j$ - value (risk share), which characterizes the binary complex "principal cause of injury - type of traumatic event"; B_j^t - rate risk (proportion) of j -th type of traumatic event; Π_i^t - rate risk (proportion) of i-th cause injuries.

In Table. 1 there are results of the calculation of risk values for its 240 varieties based on injury statistics in nine years.

Each of these types corresponds to a combination of a cause of injury Π_i and a traumatic event B_j. That is in contrast to the vague and unspecific interpretation of the reasons Π_i, kind of risk $\Pi_i B_j$ is showing such cause, which allows determining the presence or absence of the possibility of a manifestation for such reason in the workplace. In addition, quantitative estimates of different types of risk allow you to rank and identify those of them that are requiring priority attention, and also to perform other actions due to current procedures of the risk assessment and planning of prevention of the occupational injuries.

For example, a combination of causes Π_1, full title of which is design flaws, imperfection, insufficient reliability of machines, equipment and type of the traumatic event B_2 (falling of the victim) forms a kind of risk that can be interpreted as the risk of injury from falling of the victim due to the structural deficiencies of technology. Other words in contrast to the broad and largely undefined interpretation of causes Π_1 (design flaws), a variety of risk P_{III} (B_2) essentially is describing the cause of risk, allowing more clearly and purposefully influence it. Moreover, quantitative estimates of the types of risk are listed in Table. 1, allow you to rank and to identify those of them which are requiring priority attention. You can perform other actions according to current procedures of risk assessment and also plan the prevention of occupational injuries.

Analysis of calculation of the different assessments of risk listed in Table 1-3, shows that technical reasons of injury Π_1, Π_2, Π_3, Π_4 causing the largest value of the risks in conjunction with the following types of traumatic events - B_1, B_2, B_3, B_4, B_5, B_7, B_{15} for accidents with non-fatal consequences and B_1, B_2, B_3, B_4, B_5 as the risk of fatal injury. For the risks of injury with non-fatal consequence and fatal accidents the most dangerous types of risks are poor technical condition of assets Π_3 and weaknesses in the study Π_5, that can cause traffic accidents *B1*, falling the employee including falling from height of *B2* and *B3*, damage from falling objects, materials, rocks, soil *B4*, damage from exposure to moving, flying, rotating parts *B5*. For the risk without a fatal injury is typical the action of harmful and toxic substances B7 and other events, the identification of which is not required by applicable classification *B*15.

Table 1

Matrix of risk of injury by kind of events that leads to the accident and causes injury in the food industry, $\times 10^{-5}$

	$П_1$	$П_2$	$П_3$	$П_4$	$П_5$	$П_6$	$П_7$	$П_8$	$П_9$	$П_{10}$	$П_{11}$	$П_{12}$	$П_{13}$	$П_{14}$	$П_{15}$	$П_{16}$
B_1	0,223	0,149	0,475	0,149	0,597	0,075	0,075	0,075	0,075	0,373	0,746	0,746	0,522	0,075	0,075	0,075
	2,405	1,430	5,394	2,600	4,484	0,390	0,325	0,975	0,780	18,458	7,994	5,199	7,864	2,600	1,625	3,184
B_2	0,106	0,071	0,212	0,071	0,283	0,035	0,035	0,008	0,035	0,177	0,353	0,353	0,247	0,035	0,036	0,036
	1,526	0,907	3,422	1,650	2,845	0,247	0,206	0,618	0,495	11,710	5,071	3,298	4,990	1,649	1,031	2,020
B_3	0,071	0,047	0,141	0,047	0,188	0,024	0,024	0,024	0,024	0,118	0,236	0,236	0,165	0,024	0,024	0,024
	0,888	0,528	1,991	0,960	1,655	0,144	0,120	0,360	0,288	6,814	2,951	1,919	2,903	0,960	0,600	1,176
B_4	0,071	0,047	0,141	0,047	0,188	0,024	0,024	0,024	0,024	0,118	0,236	0,236	0,165	0,024	0,024	0,024
	0,827	0,492	1,856	0,894	1,543	0,092	0,112	0,335	0,268	6,351	2,751	1,789	2,706	0,894	0,560	1,096
B_5	0,082	0,055	0,165	0,055	0,220	0,012	0,028	0,028	0,028	0,137	0,275	0,275	0,192	0,028	0,028	0,028
	0,922	0,548	2,069	0,997	1,720	0,150	0,049	0,374	0,300	7,079	3,066	1,994	3,016	0,997	0,623	1,221
B_6	0,035	0,008	0,071	0,024	0,094	0,004	0,012	0,012	0,012	0,059	0,118	0,118	0,082	0,012	0,012	0,012
	0,302	0,179	0,677	0,326	0,562	0,125	0,041	0,122	0,141	2,315	1,003	0,652	0,986	0,326	0,204	0,400
B_7	0,012	0,008	0,024	0,039	0,031	0,004	0,004	0,004	0,004	0,020	0,039	0,039	0,028	0,004	0,004	0,004
	0,560	0,333	1,257	0,606	1,045	0,091	0,076	0,227	0,182	4,300	1,862	1,211	1,832	0,606	0,380	0,742
B_8	0,012	0,008	0,024	0,008	0,031	0,004	0,004	0,004	0,004	0,020	0,008	0,039	0,028	0,004	0,004	0,004
	0,078	0,046	0,174	0,084	0,145	0,012	0,010	0,031	0,025	0,595	0,258	0,168	0,254	0,084	0,052	0,103
B_9	0,012	0,008	0,024	0,008	0,031	0,039	0,004	0,004	0,004	0,020	0,039	0,039	0,028	0,004	0,004	0,004
	0,216	0,128	0,483	0,233	0,402	0,035	0,030	0,087	0,070	1,654	0,716	0,466	0,705	0,233	0,145	0,285
B_{10}	0,012	0,008	0,024	0,008	0,031	0,004	0,004	0,004	0,004	0,020	0,004	0,039	0,028	0,004	0,004	0,004
	0,043	0,026	0,097	0,143	0,080	0,007	0,006	0,017	0,014	0,331	0,046	0,093	0,141	0,046	0,029	0,057
B_{11}	0,012	0,008	0,024	0,008	0,031	0,004	0,004	0,004	0,004	0,020	0,039	0,039	0,028	0,004	0,004	0,004
	0,043	0,026	0,097	0,046	0,080	0,007	0,006	0,017	0,014	0,331	0,143	0,093	0,141	0,046	0,029	0,057
B_{12}	0,012	0,008	0,024	0,008	0,031	0,004	0,004	0,004	0,004	0,020	0,039	0,039	0,028	0,004	0,004	0,004
	0,078	0,046	0,174	0,084	0,145	0,012	0,010	0,031	0,025	0,595	0,258	0,168	0,254	0,084	0,052	0,103
B_{13}	0,012	0,008	0,024	0,008	0,004	0,004	0,004	0,004	0,004	0,020	0,008	0,008	0,028	0,004	0,004	0,004
	0,043	0,026	0,097	0,046	0,080	0,007	0,006	0,017	0,014	0,035	0,128	0,093	0,141	0,046	0,029	0,057
B_{14}	0,012	0,035	0,024	0,039	0,031	0,004	0,004	0,004	0,004	0,020	0,039	0,039	0,028	0,004	0,004	0,031
	0,216	0,143	0,483	0,232	0,402	0,331	0,030	0,087	0,070	1,654	0,716	0,466	0,705	0,233	0,145	0,285
B_{15}	0,024	0,016	0,047	0,016	0,063	0,008	0,008	0,008	0,008	0,039	0,079	0,079	0,055	0,039	0,008	0,008
	0,569	0,338	1,276	0,615	1,061	0,134	0,077	0,231	0,184	4,366	1,891	1,230	1,860	0,615	0,384	0,753

For the accidents with fatal and non-fatal consequence the most dangerous is the organizational causes $П_{10}$, $П_{11}$, $П_{12}$, $П_{13}$, that can lead to the traffic accidents B1, as well as to the following types of traumatic events: *B2, B3, B4, B5, B6* (Table 2-3).

For types of risk from organizational reasons without fatal consequences the most dangerous injury is caused by exposure to harmful and toxic substances *B7*, damage from exposure to ionizing radiation *B8*, damage from exposure to fire *B14* and other events, the identification of which is not required by applicable classification *B15*. Psychophysiological $П_{14}$, $П_{15}$ and other causes of injury, identification of which is not required by applicable classification $П_{16}$ for the accidents without fatalities predetermine the largest value of risks in conjunction with the following types of traumatic events – B_1, B_2, B_3, B_4, B_5 (Table 3).

These estimates of different risk injury due to technical, organizational and psychophysiological reasons for allowing more detail to take into account causal relationships that occur during injury in the food industry, providing a more targeted, and therefore effective preventive measures.

Thus, the analysis of matrices of risk for the food industry allowed to reveal a characteristic feature - the risks are distributed very unevenly among the 240 analyzed a variety of reasons.

Table 2

Causes of the 50% and 75% of risks of fatal injury in the food industry, 2003–2012

	$П_1$	$П_2$	$П_3$	$П_4$	$П_5$	$П_6$	$П_7$	$П_8$	$П_9$	$П_{10}$	$П_{11}$	$П_{12}$	$П_{13}$	$П_{14}$	$П_{15}$	$П_{16}$
B_1	**17**	**27**	**5**	**28**	**3**	**45**	**46**	**47**	**48**	**6**	**1**	**2**	**4**	**42**	**43**	**44**
B_2	**36**	**51**	**19**	**53**	**9**					**23**	**7**	**8**	**12**			
B_3	**49**		**29**		**21**					**32**	**15**	**13**	**24**			
B_4	**50**		**30**		**22**					**33**	**16**	**14**	**25**			
B_5	**38**		**26**		**18**					**31**	**11**	**10**	**20**			
B_6			**52**		**37**						**34**	**35**	**39**			
B_7																
B_8																
B_9																
B_{10}																
B_{11}																
B_{12}																
B_{13}																
B_{14}																
B_{15}											**40**	**41**				

Table 3

Causes of the 50% and 75% of risks of non-fatal injury in the food industry, 2003–2012

	$П_1$	$П_2$	$П_3$	$П_4$	$П_5$	$П_6$	$П_7$	$П_8$	$П_9$	$П_{10}$	$П_{11}$	$П_{12}$	$П_{13}$	$П_{14}$	$П_{15}$	$П_{16}$
B_1	**27**	**49**	**8**	**25**	**12**					**1**	**3**	**9**	**4**	**26**	**46**	**17**
B_2	**48**		**15**	**44**	**22**					**2**	**10**	**16**	**11**	**45**		**30**
B_3			**32**		**41**					**6**	**20**	**33**	**21**			
B_4			**37**		**47**					**7**	**23**	**39**	**24**			
B_5			**29**		**40**					**5**	**18**	**31**	**19**			
B_6										**28**						
B_7										**13**	**35**		**38**			
B_8																
B_9										**42**						
B_{10}																
B_{11}																
B_{12}																
B_{13}																
B_{14}										**43**						
B_{15}			**50**							**14**	**34**		**36**			

Analysis of the distribution of ranked values of different risks in food industries,results are presented in (Table 2-3), showed that 75% of the risk of fatal injuries and non-fatal corresponds to 20% allocated in the matrix of variety of risk. This is consistent with a wide regularity, called the principle of 20/80.

In contrast to the known results of the analysis of the causes of injury, obtained in work regularities and features of the distribution causes of injury by various of reasons substantially expand and elaborate knowledge of the immediate causes of injury and allow a clear choice and justify preventive measures.

We proposed an approach to the research of the main causes and types of events, which occur during getting injury in the food industries. This approach is in the matrix of risk of injury for 15 kinds of events, which led to accidents, and 16 causes of injuries, background information of which is shown in the official sources. The matrix of risk provides quantitative statistical assessment 240 different causes of risk for binary groups "cause of accident - kind of traumatic event". Presence in the matrix of risks quantitative values enables for ranking of different types of risk in view of their seriousness. In its turn it facilitates the choice of preventive measures and provides a more effective impact on total risk (because of targeting prevention on different kind with the largest values of risk indicators). The peculiarity of matrices of risks is that the comparison of two matrices The peculiarity of matrices of risks is that the comparison of two matrices (injury with fatalities and with no such effects) allows to get additional characterization of injury severity for the practice of risk analysis as the number of victims with no fatal consequences on one fatal.

For the first time was clarified the regularity of ranking of the binary interrelations "Reason of the injury - kind of the traumatic event" for the food industries, which is that only near 20% of them contribute 75% of the risk of injury.

Conclusions

Research of the causation of injury in the food industry based on calculating conditional probabilities brings together disparate statistics on the causes of accidents and the types of events that result in injury into a single system of quantitative estimates of different risks for pairs "cause - the kind of traumatic event". This method specifies causal relationships laid down in the official statistics on occupational injuries, and more clearly and unambiguously indicates the measures and means to effective prevention accidents at the food industry enterprises.

References

1. Vodyanik A.E., Evtushenko O.V. (2012), Issledovanie proizvodstvennogo travmatizma so smertel'nym iskhodom v pishchevoy promyshlennosti Ukrainy, *Nauchnye trudy Odesskoy natsianol'noy akademii pishchevykh tekhnologiy*, 42(1), pp. 408 – 414.
2. Yevtushenko O.V. (2011), Analiz statystyky vyrobnychoho travmatyzmu v kharchovii promyslovosti Ukrainy, *Kharchova promyslovist*, 10, pp. 169 – 174.
3. Yevtushenko O.V., Huts V.S. Prychyny, dzherela i obstavyny vyrobnychoho travmatyzmu v miasnii promyslovosti Ukrainy, *Kharchova promyslovist*, 13. pp. 158 – 164.
4. Yevtushenko O.V., Vodianyk A.O. (2012), Pidvyshchennia rivnia bezpeky pratsi na pidpryiemstvakh kharchovoi promyslovosti, *Problemy okhorony pratsi v Ukraini*, 24, pp. 26 – 37.
5. Koshil O. H., Kostrovenko L. N. (2010), *Statystychnyi biuleten. Travmatyzm na vyrobnytstvi u 2003–2009 rokakh*, Kyiv.
6. Kalachova I. (2013), *Statystychnyi biuleten. Travmatyzm na vyrobnytstvi u 2010–2012 rokakh,* Kyiv.
7. Vodianyk A.O. (2008), *Metodolohichni osnovy vrakhuvannia faktora ryzyku v profilaktytsi vyrobnychoho travmatyzmu*: Phd tethis, Kyiv.

8. Kremer N.Sh. (2004), *Teoryia veroiatnostei y matematycheskaia statystyka*, YuNYTY-DANA, Moskva.
9. (2008), *Poriadok rozsliduvannia ta vedennia obliku neshchasnykh vypadkiv, profesiinykh zakhvoriuvan i avarii na vyrobnytstvi*, Kyiv.
10. (2012), Occupational risk management under the OHSAS 18001 standard: analysis of perceptions and attitudes of certified firms, *Journal of Cleaner Production*, 24, pp. 36-47.
11. O.Evtushenko, N. Volodchenkova (2012), The distribution of occupational injury in the food industry in Ukraine, *The sale of the global crisis. Quality and performance*, pp. 59 - 63.
12. O. Evtushenko, I. Klepikov (2013), Exploration of occupational injuries in food industry of, *Ukrainian journal of food science*, 1(1), pp. 49-55.
13. Todd D. Smith, David M. DeJoy (2012), Occupational Injury in America: An analysis of risk factors using data from the General Social Survey (GSS), *Journal of Safety Research,* 43(1), pp. 67-74.
14. Beatriz Fernández-Muñiz, José Manuel Montes-Peón, Camilo José Vázquez-Ordás (2012), Occupational risk management under the OHSAS 18001 standard: analysis of perceptions and attitudes of certified firms, *Journal of Cleaner Production*, 24, pp. 36-47.
15. Gordon Walker, John Mooney, Derek Pratts (1998), Risk management: role of social factors in major industrial accidents, *Safety Science*, 30(1-2), pp. 173-181.