Analysis of selection factors for estimation of labour safety in the enterprises of the meat industry

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Abstract: *For the analysis and assessment of safety in the meat industry due to incompletely statistics in the field of agriculture for identifying factors that affect the safety, it is advisable to use the method of expert estimations. At the initial stage of experimental work, when we should separate the most important factors according to interview of specialists, from large number of factors, special attention is given to a priori method of ranking factors. Feature of the method is that the factors which, according to a priori information can have a significant impact, are ranked by decreasing their influence. The aim is to evaluate and identify the aggregate of factors that affect the risk of injury to workers meat processing plants during manufacturing operations in the workplace. Studies were conducted using the method of a priori ranking factors on the results of the expert survey. Analysis of the results of expert evaluation with sufficient consensus view of experts (95%) allowed us to rank and prioritize factors, what are affecting on overall injury rate during the process, and also importance of measures that will improve the level of safety in meat processing plants. The most significant impact on injuries and occupational diseases of workers meat processing enterprises has organizational and technical group factors. These factors, above all, should be considered when designing measures for safety in the workplace enterprises of meat industry.*

Key words: *Safety and health at work, occupational injury, risk assessment, matrix, factors, method.*

INTRODUCTION

Despite overall tendency of decreasing number of accidents in the Ukrainian food industry, generally the average level of accidents and occupational injuries still is extremely high. Only during 2003-12 years there were injured over 9.5 thousands of people in the food industry. The 599 of them died [3-5]**.**

For the analysis and assessment of safety in the meat industry due to incompletely statistics in the field of agriculture for identifying factors that affect the safety, it is advisable to use the method of expert estimations. The reliability of peer review is based on the assumption that reliability ratings are guaranteed if experts will coordinate their observation and analysis [1-2]. Using peer review it's assumed that the opinion of the expert group is more reliable than review of individual expert. The method of collective peer review was very widespread and is commonly used to transfer the experience of leading experts in almost all fields of knowledge and production.

At the initial stage of experimental work, when we should separate the most important factors according to interview of specialists, from large number of factors, special attention is given to a priori method of ranking factors. Feature of the method is that the factors which, according to a priori information can have a significant impact, are ranked by decreasing their influence. The influence of each factor is measured by the value of rank, which is allotted by an expert to this factor, while all factors are being ranked with accounting of projected impact on the optimization settings. In preparing expert opinions by their polls, everyone is invited to complete a questionnaire in which are shown these factors, their dimension intervals. When completing the questionnaire, the expert determines the location of factors that is being ranked.

The aim is to evaluate and identify the aggregate of factors that affect the risk of injury to workers meat processing plants during manufacturing operations in the workplace.

MATERIAL AND METHODS

Studies were conducted using the method of a priori ranking factors on the results of the expert survey. Processing of the results was carried out using PC software packages.

RESULTS AND DISCUSSIONS

Based on the method of peer review in accordance with the requirements [1-2] the

performed data processing by method of a priori ranking factors in the following order:

1. The results of peer review data are presented in a matrix of rank.

Matrix of results of expert evaluation indicators

Experts	Factors				
	X_1	X_2	…	…	X_i
1	a_{11}	a_{12}	…	…	a_{1i}
2	a_{21}	a_{22}	…	…	a_{2i}
j	a_{j1}	a_{j2}	…	…	a_{ji}

2. Calculates the sum of ranks for factors $\left(\sum_{1}^{m} a_{ij}\right)$, where a_{ij}- rank of each *i*-factor of *j*-experiment; *m* – number of experts; *n* – number of factors.

3. Determination of the average amount of ranks: $\frac{\sum_{1}^{n}\sum_{1}^{m} a_{ij}}{n}$.

4. Calculated deviation from the average amount of ranks:

$$\Delta i = \sum_{1}^{m} a_{ij} - \frac{\sum_{1}^{n}\sum_{1}^{m} a_{ij}}{n}$$

5. Identifying squares of deviations from the average sum of ranks, i.e. the sum of squares of deviations:

$$s = \sum_{1}^{m} (\Delta i)^2$$

6. These data allow us to build high priori chart ranks, after assessing the degree of agreement opinions of the group of experts on the importance of selected factors on the coefficient of concordance (agreement), ω:

$$\omega = \frac{12s}{m^2(n^3 - n) - m\sum_{1}^{m} T_j}$$

where $Tj = \Sigma(t_j^3 - t_j)$; t_j – number of equal ranks in *j*-ranking.

7. Testing conditions agreement of expert opinion:

$\omega = 1$ – evaluation of all experts are the same;

$\omega = 0$ – experts gave different results and views.

8. Valuing coefficient of concordance was carried out on the criterion χ2-distribution with the number of degrees of freedom *f*=*n*–1.

The value of χ2-criterion was got according to formula:

$$\chi^2 = \frac{12s}{mn(n+1) - \frac{1}{n-1}\sum_{1}^{m} T_j}$$

The hypothesis about the availability of coordination of expert opinion may be accepted, if the given number of degrees of freedom tabular χ2 value less than estimated for the 5% level of local importance.

Thus, the weight of each factor and the consistency of experts' opinions are determined during the process of peer review.

9. Assessing agreement opinions of all the experts should be built high ranking chart by plotting on the horizontal axis factors, and the vertical axis - the amounts ranks. The lower the rank sum of this factor, the higher the spot on the chart. The factor significance is estimated thanks to previously built diagram. In case of uneven distribution of exponential decrease, some factors can be excluded from further calculations. If the distribution is uniform, it is recommended to include all the factors into the experiment. In

situations with a large number of factors, apart from the general agreement of expert opinion, it is considered usage of the χ2-distribution and approval for each factor separately.

Let's have a look on a priori feature ranking factors in assessing the impact on safety and occupational diseases of workers meat processing plants. In the preliminary study of the research object, the five experts were interviewed (m = 5). The survey data were used for the a priori ranking factors in order to identify the most important ones. The survey was conducted by questionnaire, which contains seven factors (n = 7) to be ranked considering the extent of their exposure to the risk of injury. Were considered factors that characterize work safety: organizational, technical, skill, health, physiological, physical, and random.

Matrix ranking obtained from questionnaires is presented in Table 1.

$$\omega = \frac{12 \times 661,18}{25(7^3 - 7) - 5 \times 24} = 0,95$$

Since the value of the coefficient of concordance is significantly different from zero, we can assume that between the expert's opinions is connection.

The significance of the coefficient of concordance tested by χ2-test based on the formula:

$$\chi^2 = \frac{12 \times 661,18}{5 \times 7(7+1) - \frac{1}{7-1} \cdot 24} = 28,75$$

Due to the fact that the table value of χ2-criterion less than estimated, it can be predicted with 95% of probability that the opinion of experts on the impact of factors is consisted according to the concordance coefficient ω = 0,95. This allows you to build a high ranking chart for these factors (Fig. 1).

Table 1

Matrix ranking of individual components of industrial and technological factors affecting the injuries and diseases of the meat industry workers

Experts (*m*)	Factors (*n*=7)							$T_j = \sum(t_j^3 - t_j)$
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	
1	6,5	5,5	4,5	4,0	4,0	2,0	1,5	6
2	7,5	6,5	5,0	3,5	3,5	2,0	1,5	6
3	8,0	6,5	4,5	3,5	4,0	1,5	2,0	0
4	8,5	5,5	5,0	4,0	3,5	2,0	2,0	6
5	7,5	5,0	5,5	4,0	4,0	1,5	2,0	6
$\sum_1^m a_{ij}$	38,0	29,0	24,5	19	19	9	9	$\sum_1^5 \sum_1^7 a_{ij} = 147,5$
Δi	16,93	7,93	3,43	-2,07	-2,07	-12,07	-12,07	
$(\Delta i)^2$	286,62	62,88	11,76	4,28	4,28	145,68	145,68	*S*=661,18

According to the expert data processing method of a priori ranking factors can draw the following conclusions.

The most significant impact on injuries and occupational diseases of workers meat processing enterprises has organizational and technical group factors.

These factors, above all, should be considered when designing measures for safety in the workplace enterprises of meat industry.

Results of ranking in the definition of occupations suggest that the most susceptible to injury are next groups of workers: livestock killers, drivers, loaders, mechanics who work on maintenance and repair of equipment, as well as meat handlers who work directly with traumatic equipment.

The results of data processing of the expert's survey about identifying the causes of deliberate violations of security workers during the execution of the process showed that in the first place of importance is to ignorance the dangers, confidence in the ability to avoid an accident in the event of a dangerous situation. The most important reasons for deliberate violations of safety should also include poor training in safe methods of work, where often is presented formalism.

The survey of experts on the potential causes of occupational injuries show that currently there is a situation when the number of industrial buildings that are in poor condition, is growing every year, as evidenced by the first reason - poor technical condition of production facilities, buildings, area. The second reason is attraction of nonprofessional workers due to the fact that most of the work at the enterprises of the meat industry associated with the occurrence of hazards and require special training. The third and fourth reasons indicate the need to improve the technology and develop engineering solutions to improve equipment and facilities at enterprises of the meat industry. During processing a number of works according to the process at the meat industry and a number of harmful and dangerous production factors on primary production workers there is a significant need to develop individual and collective protection of workers.

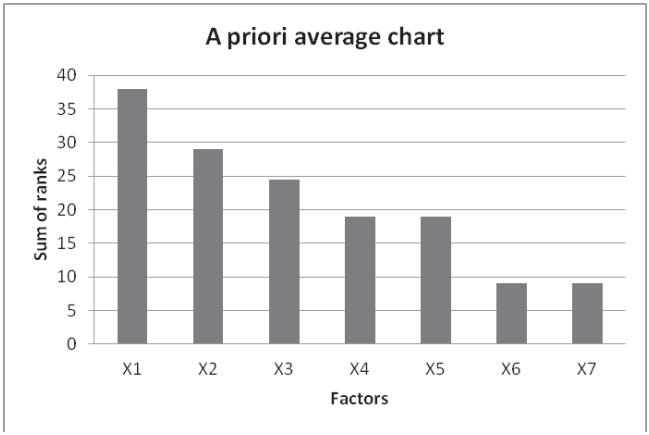

Fig. 1. Average priori chart ranks of industrial and technical factors

Technological equipment of most meat processing plants is obsolete and just lost lifetime warranty. Much of the equipment used at slaughter and processing of livestock, performs its technological features, but has virtually no defense mechanisms.

Ranking according to the most traumatic equipment in the meat industry showed that most workers injured through operations with steam and water heating boilers, by conveyors; by equipment for the primary processing of livestock, forcemeat mixers, pumping stations, machines for meat dumplings production, lines of sausage production etc.

Experts have confirmed that the most effective measure, the implementation of which would achieve reduction of occupational injuries, is to develop programs for learning and knowledge control of safety, especially for jobs of employees of the meat industry.

The second and third steps is the development and implementation of safety locking devices for stationary machines drives, improving of blocking moving parts of equipment for meat processing enterprises.

CONCLUSION

According to the expert data processing method of a priori ranking factors, it can be concluded that the analysis of the results of expert evaluation with sufficient consensus view of experts (95%) allowed us to rank and prioritize factors, what are affecting on overall injury rate during the process, and also importance of measures that will improve the level of safety in meat processing plants.

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This paper has been reviewed