Occupational accident risk assessment in agricultural work using the FMEA model

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Abstract

This article presents a novel method for occupational accident risk assessment using the Failure Mode and Effects Analysis (FMEA) model. Its primary objective is to verify the applicability of the FMEA model for measuring the risk of agricultural accidents and implementing measures to eliminate such risks. The model in question is most commonly applied to quality management within manufacturing enterprises. It facilitates the monitoring and elimination of production error risks.

Employee absence, the need for replacement, and medical and rehabilitation expenses result in financial losses. Accidents can also lead to losses resulting from damage to machinery and equipment, while breaches of the law may result in administrative penalties. Preventive measures aimed at eradicating agricultural accidents should be implemented continuously and closely monitored.

To verify the premise that the FMEA model can be applied to agricultural risk management, the author utilised occupational accident statistics alongside a farm-based questionnaire survey regarding occupational hazards and potential resulting incidents.

An investigation into accident causes and hazards using this method indicates that the greatest risks involve: being struck or crushed by mechanically transported materials and objects; being run over, struck, or caught by moving transport vehicles; being caught or struck by the moving parts of machinery and equipment; as well as fire, explosion, and electrocution due to working near power lines.

Keywords: Failure Mode and Effects Analysis, risk of agricultural occupational accidents, accident risk management.

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Occupational accidents in agricultural production

Agriculture is the economic sector with the highest incidence of occupational accidents[1]. The machinery, chemicals, and livestock production involved in agricultural activities mean that it is impossible to permanently eliminate all hazard-inducing factors. The definition of an agricultural occupational accident is stipulated in the Act of 20 December 1990 on the Social Insurance of Farmers. Pursuant to Article 11 of the aforementioned Act, an "agricultural occupational accident is deemed to be a sudden event caused by an external factor, which occurred during the performance of activities related to agricultural operations or in connection with such activities:

- on the premises of the farm operated by the insured person or where they are permanently employed, or on the premises of a household directly associated with the said farm, or
- whilst the insured person is commuting from their residence to the farm referred to in point 1, or on the return journey, or
- during the performance of ordinary activities related to agricultural operations outside the premises of the farm referred to in point 1, or in connection with the performance of such activities, or
- whilst commuting to the place where the activities referred to in point 3 are performed, or on the return journey"[2].

It should be noted that the legislator does not classify every accident involving an individual insured with the Agricultural Social Insurance Fund (KRUS) as an agricultural occupational accident. In accordance with the regulations, an agricultural occupational accident only occurs when the incident is linked to activities genuinely performed in relation to agricultural production (e.g., ploughing, handling livestock), rather than to everyday activities (e.g., cooking dinner for the family).

According to available data, 9,930 accidents were reported to KRUS in 2024, and 7,835 lump-sum compensation payments were disbursed for health impairment or death resulting from agricultural occupational accidents[3]. The cited statistics, when compared to previous years, indicate an improvement in the safety of agricultural production work; nevertheless, the number of accidents remains high.

1. A. Chmarycz, *Pojęcie wypadku przy pracy rolniczej*, "Bezpieczeństwo Pracy. Nauka i Praktyka" 2018, nr 7, p. 6.
2. Ustawa z dnia 20 grudnia 1990 o ubezpieczeniu społecznym rolników, Dz. U. 1991 nr 7 poz. 24.
3. KRUS, *Wypadki przy pracy i choroby zawodowe rolników oraz działania prewencyjne KRUS w 2022 roku*, Warszawa 2023, https://www.gov.pl/web/krus/wypadki-przy-pracy-rolniczej, accessed 8.12.2025.

The literature indicates that, over recent years, accidents have been caused by the following events:

- falls of persons;
- being caught or struck by the moving parts of machinery and equipment;
- being struck, crushed, or bitten by animals;
- other events[4].

The breakdown of accidents reported to KRUS in 2024 (presented in Table 1) reveals that falls of persons account for over half of all reported incidents. These encompass both slips occurring at ground level and falls from height, agricultural machinery, trees, attics, etc. A significant issue is posed by accidents involving animals, which are inherently unpredictable and may panic or act aggressively in response to certain stimuli. The causes of such accidents are often identified as improper handling, startling the animals, and approaching livestock from behind. Accidents related to being caught or struck by the moving parts of machinery constitute approximately one-tenth of all accidents. These are most frequently associated with inadequate securing of agricultural machinery during operation, a lack of appropriate safeguards, improper tool handling by operators, and the placement of limbs within hazard zones.

Table 1. Structure of accidents by accident groups in 2024

Type of event	Quantity	Percentage share
Falls of persons	4,087	52.2%
Falling objects	512	6.5%
Contact with sharp manual tools and other sharp objects	329	4.2%
Being struck or crushed by mechanically transported materials and objects	168	2.1%
Being run over, struck, or caught by moving transport vehicles	91	1.2%
Being caught and struck by the moving parts of machinery and equipment	817	10.4%
Being struck, crushed, or bitten by animals	940	12%
Fire, explosion, impact of natural forces	46	0.6%
Sudden illnesses	106	1.4%
Exposure to extreme temperatures	41	0.5%
Exposure to hazardous materials	13	0.2%
Others	685	8.7%

Source: KRUS, Komunikat o wypadkach przy pracy i chorobach zawodowych rolników w 2024 r., Warszawa 2025.

4. W. Gaweł, I. Maczewska-Borny, M. Poławska, *Wypadki w gospodarstwach rolnych. Analiza przypadków*, "Ubezpieczenia w Rolnictwie – Materiały i Studia" 2024, nr 2(82), p. 340.

Enhancing occupational safety in agriculture is undoubtedly linked to the modernisation of machinery fleets, the introduction of novel production methods, and the professionalisation of work organisation[5]. There is a plethora of methods for preventing occupational accidents: supervision, the popularisation of best practices and knowledge through training, and the modernisation of farm infrastructure. However, the application of modern technologies has its limitations, and even the most advanced technical facilities cannot protect against certain types of incidents, particularly those arising from human error or negligence. Various proposals for prevention can be found in the literature. KRUS implements preventive measures through, inter alia, education and the dissemination of health and life protection principles, advocating for the proper production and distribution of agricultural agents, equipment, and protective clothing, as well as informing farmers about methods for preventing occupational diseases. These activities also encompass familiarising farmers with post-accident procedures and the fundamentals of pre-medical first aid, alongside initiatives aimed at eliminating hazards by promoting:

- the use of occupational safeguards;
- the improvement of yard surfaces and traffic routes on farms;
- the utilisation of platforms and ladders equipped with anti-tilt and anti-slip protections when working at height;
- the elimination of thresholds and steps in buildings and passageways;
- the correct procedure for mounting and dismounting agricultural machinery;
- ensuring machinery and equipment are fitted with guards and protections for their moving parts;
- familiarisation with the operating manuals of the machinery and equipment in use;
- the rules for disabling the drive of machinery and equipment during repairs and adjustments;
- the proper securing of machinery, equipment, and tools both whilst stationary and in motion;
- the principles of safe timber harvesting for farm requirements;
- the safe coupling of agricultural machinery and equipment;
- the necessity of ensuring animal welfare and appropriate treatment, as well as understanding their physiology and natural behaviours;
- maintaining the psychophysical condition of farmers through the promotion of a healthy lifestyle, disease prevention and diagnostics, proper work organisation

5. Ł. Kuta, *Wpływ inwestycji w gospodarstwach rolnych na poprawę bezpieczeństwa rolników*, "Inżynieria Rolnicza" 2013, z. 3(145), t. 1, pp. 198–199.

(e.g., preventing the accumulation of tasks and overtiredness), and methods for preventing musculoskeletal strain[6].

P. Lundqvist[7] suggests focusing on educational activities, supporting and motivating farmers to adopt safer working practices, and utilising injury prevention measures on their farms. Conversely, A. Groborz[8] highlights methods such as:

1. Motivating farmers to conduct regular technical inspections and modernise their machinery fleets.
2. Ensuring a safe workstation. Falls from height, including from ladders, and slips on wet surfaces are common accidents. Therefore, it is recommended to install railings at all types of drop openings in building floors, inspection chambers, excavations, and other hazardous locations.
3. Maintaining tidiness in the workplace.
4. The correct method of dismounting machinery.
5. The use of personal protective equipment, including hand and foot protection during tasks, as well as respiratory protection when applying plant protection products.
6. Continuous training regarding prevailing hazards and their prevention, as well as the correct usage of protective equipment, machinery, and devices.
7. The promotion of occupational safety and health.

The selection of safety management methods in agricultural work should be tailored to the nature of the operations, the equipment utilised, and the factors elevating risk. Contemporary farms, despite dynamic mechanisation and technological advancement, can still represent a hazardous working environment. The risk of accidents arising from working with machinery, chemicals, animals, or weather conditions is high and diverse. Within this context, effective safety management becomes paramount.

In response to emerging hazards, appropriate accident prevention methods must be selected. One approach to hazard analysis that facilitates the implementation of accident prophylaxis is the operational risk analysis method using FMEA (Failure Mode and Effects Analysis) or FMECA (Failure Modes, Effects, and Criticality Analysis).

Accident prevention is associated with undertaking actions that interrupt the sequence of events leading to an accident. It is necessary to determine how this sequence emerged and why the conditions conducive to it arose. This is achievable by conducting a meticulous analysis of the event, whilst simultaneously acknowledging

6. KRUS, *Wypadki przy pracy i choroby zawodowe rolników oraz działania prewencyjne KRUS w 2022 roku*, Warszawa 2023.
7. P. Lundqvist, *Możliwości zmniejszenia liczby śmiertelnych obrażeń w szwedzkim rolnictwie dzięki programowi prewencyjnemu*, "Ubezpieczenia w Rolnictwie – Materiały i Studia" 2021, nr 2(76), pp. 86–87.
8. A. Groborz, *Jak zapobiegać wypadkom w rolnictwie indywidualnym*, "Bezpieczeństwo Pracy" 2012, nr 7, pp. 9–11.

that these causes are typically identified at the site where the accident occurred[9]. However, it is challenging to perform such an analysis ex-ante, i.e., before it transpires. It is considerably easier to investigate the cause-and-effect chain leading to an accident after it has taken place.

FMEA analysis in accident risk management

Defining the concept of risk precisely poses a substantial challenge, which renders the creation of a universal and exact definition exceptionally difficult, and perhaps even impossible. It may be understood differently depending on the context and the nature of human activity. In colloquial terms, risk can be described as an event that is not bound to happen, but if it does occur, it may result in a loss or a gain[10].

The term "risk" is very frequently equated with gambling, uncertainty, and random events. The word is linked to the Latin "riscare", meaning "to dare". In this context, it represents a consequence of human activity, rather than an inescapable fate[11]. Colloquially, risk is perceived as a measure of the probability of an adverse event occurring, which may be the outcome of a decision made or stem from factors beyond our control. This adverse event and its ramifications are associated with health impairment, material losses, and other negative consequences.

A multitude of definitions of risk exists within the literature – a concept which, moreover, continually evolves. For instance, J.K. Sinkey comprehends risk as the uncertainty associated with future events or the outcomes of decisions[12]. A.H. Willet defines risk as the uncertainty surrounding the occurrence of specific effects of the state of nature. It represents a certain objective regularity characteristic of the real world, which is subjectively perceived and interpreted by the individual[13]. Contemporarily, the definition of risk emphasises the ability to estimate and determine its level via the probability (mathematical, statistical, or even roughly estimated) of the occurrence of certain adverse factors. Risk is supposed to differ from uncertainty in that risk is measurable, whereas uncertainty regarding the occurrence of certain phenomena

9. A. Górny, *Wykorzystanie FMEA procesu w analizie zdarzeń wypadkowych i doskonaleniu warunków wykonywania pracy* [in:] *Zastosowania Ergonomii. Wybrane kierunki badań ergonomicznych w 2016 roku*, Wrocław, Wydawnictwo Polskiego Towarzystwa Ergonomicznego, 2016, p. 4.
10. W. Chmielowiec-Ronka (ed.), *Ubezpieczenia*, Warszawa, CH Beck, 2016, s. 11.
11. P.L. Bernstein, *Przeciw bogom. Niezwykłe dzieje ryzyka*, Warszawa, WIG-Press, 1997, p. 19.
12. J.F. Sinkey Jr., *A Multivariate Statistical Analysis of the Characteristics of Problem Banks*, "Journal of Finance" 1975, Vol. 30, p. 23.
13. O.G. Wood Jr., *Evolution of the concept of risk*, "The Journal of Risk and Insurance" 1964, Vol. 31, No. 1, p. 86.

is immeasurable[14]. I. Pfeffer points out that risk can be measured via probability, while uncertainty is a state of mind measured by the degree of belief. These two concepts cannot be synonymous; risk only exists when an individual is cognisant of it[15].

Risk, in contrast to uncertainty, is a narrower, more objective concept, detached from the element associated with surprise; it is measurable and manageable[16]. Risk management should be equated with activities aimed at its mitigation. It involves the identification and control of areas or events that may lead to undesirable outcomes. The risk management process comprises four distinct stages: identification, classification, measurement, and response methods[17].

Risk identification is linked to the isolation of hazards and obstacles to achieving a predetermined goal. It is a crucial element, as overlooking certain risk sources can lead to erroneous conclusions and the implementation of actions that fail to yield the expected results. At this stage, statistical data, published reports, and the opinions of experts, managers, and employees can be utilised[18].

For the purposes of this paper, the identification of the sources for the list of agricultural occupational accidents was conducted based on statistical data published by KRUS and a questionnaire carried out on a single farm. This is a farm situated in the Wielkopolskie Voivodeship, engaged exclusively in crop production across a cultivated area of 410 ha. There have been no accidents on this farm for the past 10 years (with the exception of minor bruises, cuts, and insect stings, which were neither reported nor recorded anywhere). In the owner's opinion, all mechanical equipment is fully functional, regularly maintained, repaired when necessary, and equipped with appropriate safeguards. Employees utilise personal protective equipment, and tasks at height are conducted with paramount caution and the use of safeguards such as safety helmets, gloves, or footwear with high-grip soles. Protective railings have been installed in areas deemed hazardous.

Identified hazards are classified in terms of their frequency or the probability of their occurrence, and the consequences a given hazard entails. Events with a minimal frequency of occurrence and negligible negative consequences are of little significance. Primary importance is attributed to events with a high probability of occurrence that

14. F.H. Knight, *Risk, Uncertainty and Profit*, Boston, Houghton Miffin Company, 1921, pp. 19–20.
15. I. Pfeffer, *Fine Arts: A Problem in Risk Management*, "California Management Review" 1972, Vol. 15(2), p. 119.
16. E. Kowalewski, *Ryzyko w działalności człowieka i możliwości jego ograniczania* [in:] *Ubezpieczenia gospodarcze*, red. T. Sangowski, Warszawa, Poltext, 2001, pp. 48–49.
17. C.L. Pitchard, *Zarządzanie ryzykiem w projektach. Teoria i praktyka*, Warszawa, WIG PRESS, 2002, p. 343.
18. A. Adamska, *Ryzyko w działalności przedsiębiorstwa – podstawowe zagadnienia* [in:] *Ryzyko w działalności przedsiębiorstw. Wybrane aspekty*, A. Fierla (red.), Warszawa, SGH, 2009, p. 17.

entail exceptionally severe consequences. The purpose of classification is to rank the identified hazards from the most critical to the least important[19].

In this paper, risk classification was performed on the basis of the questionnaire conducted at the surveyed farm. It classified the probability of the occurrence of individual types of accidents and evaluated the manner in which safeguards were employed against these events.

Risk measurement consists in assigning values in accordance with the prior classification. One method of risk measurement and response is FMEA, or Failure Mode and Effects Analysis. This analysis – described in the PN-EN 60812:2009 standard – is predominantly utilised in industry and automation to identify potential failures, their causes and effects, and to assess their impact on system safety and reliability. Its objective is to pinpoint process flaws and rectify them, or to eliminate the risk associated with these flaws[20]. The aims of the FMEA method align with the principle of "continuous improvement", as it enables processes to be subjected to iterative analyses, forming the basis for introducing solutions that eradicate flaws and hazards[21].

The FMEA method is most frequently applied in production management, quality management, and for the identification of process or product flaws. Its application is intended to enhance the process and eliminate the root cause of a defect, which can be achieved by implementing appropriate corrections or improvements[22].

As part of this method, risk elements are selected based on three factors, assigned values ranging from 1 to 10:

– probability/frequency of occurrence (P),
– severity of impact (S),
– detectability index (W)[23].

The frequency of occurrence (P) refers to the probability of an occupational accident taking place on a farm. Given that in the literature the proposed values for individual indices generally relate to the probability of an error occurring in manufactured products, the following classification has been proposed:

1) almost impossible – indicates a probability close to zero, for example, if work is executed fully automatically, without human intervention.

19. Ibidem, p. 18.
20. Norma PN-EN 60812:2009.2009, Techniki analizy nieuszkadzalności systemów – procedura analizy rodzajów i skutków uszkodzeń (FMEA), Warszawa, p. 26.
21. K. Kukiełka, S. Pałubicki, *Zarządzanie jakością w wybranym procesie produkcyjnym z zastosowaniem metody FMEA*, "Autobusy. Technika, Eksploatacja, Systemy Transportowe" 2017, nr 7–8, p. 257.
22. A. Rychły-Lipińska, *FMEA – Analiza rodzajów błędów oraz ich skutków*, "Zeszyty Naukowe Wydziału Nauk Ekonomicznych" 2021, nr 1(11), p. 47.
23. J. Łańcucki (red.), *Zarządzanie jakością w przedsiębiorstwie*, Bydgoszcz, TNOiK, 1997, p. 66.

2) very low – for instance, operating modern machinery (fully equipped, with up-to-date inspections and safeguards) or navigating the farm on foot, in suitable footwear.
3) low, minor – for instance, operating machinery on which breakdowns are rarely reported, moving in motor vehicles and agricultural equipment within the farm boundaries, or traversing the terrain, fields, or the farm on foot in adverse weather conditions;
4) moderately low – driving motor vehicles (in good technical condition, compliant with regulations) on public roads and beyond the farm boundaries;
5) medium – any tasks carried out in haste, or working with corrosive substances while wearing appropriate protective equipment;
6) moderately high – any tasks at heights up to 3 metres, including work performed on deactivated agricultural machinery and elevated equipment;
7) high – tasks at heights exceeding 3 metres above ground level; any work performed without personal protective equipment, yet in footwear and clothing suited to the specific activity; work at height on activated agricultural machinery, but with safeguards deployed in accordance with the manufacturer's manual/recommendations;
8) very high – tasks involving incomplete equipment, without safeguards utilised by operators; conducting pressure, load, and testing trials; working with chemicals and corrosive substances without protection;
9) extremely high – working at heights without any fall arrest systems, using makeshift ladders constructed from nailed boards, tasks involving incomplete equipment lacking guards performed by seasonal or untrained staff;
10) almost certain – for example, clearing snow from pitched roofs without any fall protection, emergency repairs on moving machinery parts without safeguards, work on live high-voltage electrical components, working under the influence of alcohol, and tasks performed in flagrant violation of occupational health and safety regulations[24].

The next factor is the severity of impact (S), representing the magnitude of the consequences an accident entails. This index can be correlated with the extent of injuries an accident could potentially cause; it also takes values from 1 to 10, where:

1) no effect – indicates negligible impact, such as a painless, minimal epidermal graze or a minor bump to a body part;

24. Own elaboration based on: *How to Assess Risk Using FMEA*, Relyence Corporation, 2020, p. 7, https://relyence.com/wp-content/uploads/2020/09/FMEA-Risk-Assessment-White-Paper.pdf, accessed 13.12.2025.

2) very minor – signifies negligible impact, such as bruises and grazes requiring no medical treatment;
3) minor – slight cuts and minor bruises, not requiring medical intervention;
4) moderate – contusions, joint sprains, and lacerations requiring medical intervention, but without hospitalisation; injuries meet the criteria for reporting an agricultural occupational accident;
5) burdensome and requiring treatment – sprains, minor fractures necessitating reduction and rehabilitation; hospitalisation possible;
6) moderately severe – fractures of long bones (e.g., arm, leg), deep wounds, tissue damage; treatment requires hospitalisation and rehabilitation;
7) severe injuries – multiple fractures, deep puncture wounds, chest injuries; prolonged hospitalisation, considerable impairment to daily functioning;
8) very severe – comminuted fractures, major injuries to the head, internal organs, or chest, surgical intervention required; injuries may be life-threatening without medical assistance;
9) critical – loss of function (e.g., finger amputation, major internal injuries); risk of permanent impairment or disability; life-threatening injuries;
10) death or permanent disability – injuries resulting in extremely severe consequences such as the amputation of entire limbs, loss of sight, spinal cord damage, fatal injuries[25].

The final value to be estimated is the detectability index (W), indicating whether control measures can detect an irregularity and whether it can be prevented. This index also assumes values from 1 to 10, where:

1) almost complete detectability – the hazard is automatically and immediately detected without human participation or intervention (e.g., smoke, fire, or fault detectors, automated systems, full supervision);
2) very high detectability – the hazard is automatically detected by a system or sensors, but requires human verification;
3) high detectability – the hazard can be detected by personnel through regular inspections; procedures are effective, and responsible individuals diligently perform assigned tasks;
4) fairly high detectability – the hazard is typically detected via procedures or observation, but omissions are possible; there is a possibility of it being overlooked by a worker (e.g., due to distraction or fatigue);
5) moderate detectability – the possibility of detection exists, but does not always work; inspections are conducted infrequently (e.g., annually at a vehicle

25. Ibidem, p. 9.

testing station), employees do not always document the manner in which the technical condition check of a machine/device was performed;

6) low detectability – checks exist, but they are unsystematic or fail to detect certain hazards; incomplete inspection documentation or a complete lack thereof;
7) very low detectability – absence of any regular procedures, reviews, and inspections; detection depends on chance or luck;
8) minimal detectability – hazards typically located in areas invisible to employees; detecting the hazard requires dismantling or a special checking procedure that no one performs under normal circumstances;
9) negligible detectability – absence of any control systems; the hazard is only detected post-incident or by an individual possessing specialist knowledge, or is entirely disregarded by employees;
10) lack of detectability – it is impossible to detect the hazard prior to an accident, for example, a hidden technical defect, or the hazard is completely ignored by both employees and farm managers (total disregard/ gross negligence)[26].

The product of these three values yields the so-called RPN (Risk Priority Number), which facilitates the classification of hazards and the implementation of preventive measures. This number can range between 1 and 1,000, in accordance with the formula.

$$RPN = P \text{ x } S \text{ x } W$$ [27]

The calculation of risk level indices was conducted for a farm located in the Wielkopolskie Voivodeship, specialising in crop production with a total cultivated area of 410 hectares. The farm permanently employs 5 individuals, whilst during the summer season, depending on requirements, an additional 8 to 15 seasonal workers are employed. In the case under consideration, no accidents have occurred over the past 10 years. Exceptions include minor cuts, trips, and slips, which did not result in serious injuries and were not reported to KRUS.

The analysis of indices for the purpose of this paper was based on events classified in the Communiqué on occupational accidents and diseases of farmers in 2024[28], alongside a questionnaire concerning occupational hazards and accidents on the farm. The results have been compiled and presented in Table 2.

26. Ibidem.
27. J. Łańcucki, *Zarządzanie jakością w przedsiębiorstwie*, Bydgoszcz, TNOiK, 1997, p. 66.
28. KRUS, *Komunikat o wypadkach przy pracy i chorobach zawodowych rolników w 2024 r.*, Warszawa 2025.

Table 2. Risk Priority Number (RPN)

Type of event	Probability	P	S	W	RPN
Falls of persons	Moderately high	6	5	5	150
Fall from height	Moderately high	6	7	3	123
Falling objects	Moderately low	4	5	3	60
Contact with sharp manual tools and other sharp objects	High	7	4	7	196
Being struck or crushed by mechanically transported materials and objects	Low	3	9	4	108
Being run over, struck, or caught by moving transport vehicles	Low	3	9	4	108
Being caught and struck by the moving parts of machinery and equipment	Very low	2	9	4	72
Being struck, crushed, or bitten by animals	Almost impossible	1	6	1	6
Fire, explosion, impact of natural forces	Very low	2	9	8	144
Sudden illnesses	Moderately high	6	4	9	216
Exposure to extreme temperatures, including working in high summer temperatures	Medium	5	4	6	120
Exposure to hazardous materials	Medium	5	5	5	125
Accidents related to transport and commuting	Low	3	5	5	75
Working in adverse weather conditions (rain, snow, ice)	Moderately high	6	4	7	168
Working in inadequate lighting	Medium	5	6	4	120
Electrocution due to working near power lines	Medium	5	9	3	135
Electrocution due to defects in electrical installations/ equipment	Moderately low	4	6	4	96
Working in confined tanks and silos	Moderately low	4	6	3	72
Insect bites/stings (wasps, bees, ticks)	Extremely high	9	3	7	189
Overexertion, fatigue, overworking, lack of breaks	Moderately low	4	4	3	48
Operating equipment without prior training	Moderately high	6	6	2	72
Working with mechanical equipment without protective gear	High	7	5	3	105
Working with an axe and other dangerous manual tools without gloves	High	7	6	7	196
Working with toxic and corrosive substances whilst using safeguards	Moderately low	4	4	2	32
Working with toxic and corrosive substances without safeguards	High	7	6	3	126
Transporting people on a trailer	Moderately high	6	8	5	240
Working in noise without hearing protection	High	7	6	3	126

Source: Own elaboration.

Conclusions and recommendations

Using the FMEA method, an assessment was conducted on 26 distinct types of hazards prevalent in agricultural work. Among the events with the highest potential risk (i.e., those with high RPN values) are: sudden illnesses (RPN = 216), contact with sharp tools (RPN = 196), transporting people on a trailer (RPN = 240), insect bites/stings (RPN = 189), and working with an axe and other dangerous manual tools without gloves (RPN = 196). This unequivocally demonstrates that mechanical, environmental, and biological hazards (such as diseases and insect stings) constitute a significant risk factor.

The highest risk is associated with transporting people on a trailer (RPN = 240). This is linked to the moderately high probability of such an accident occurring, coupled with the extremely severe consequences of this type of event. Research indicates that a relatively high risk is associated with sudden illness (RPN = 216). In this instance, the consequences are not overly severe (S = 4); however, implementing procedures to safeguard against illness is challenging (W = 9).

High risk is also characteristic of working with sharp tools. It is difficult to introduce safeguards and protect employees from, for instance, stepping on such a tool. It must be assumed that employees adhere to the obligation to properly secure tools, use guards, and so forth. In many cases, however, it is arduous to implement procedures that will invariably be adhered to by personnel and completely eliminate the hazard. A particular case is working with dangerous tools without appropriate protective gear, such as footwear with contoured soles and reinforced toe caps. These are items of personal protective equipment with which every employee should be equipped. The use of gloves, safety footwear, workwear, and in many instances safety goggles, alongside the elimination of incomplete, damaged, or worn-out tools, should be mandatory. Good work organisation is also essential, encompassing the storage of hazardous tools in designated areas, clearing up after task completion, and ensuring adequate lighting. One must avoid haste and usage of tools in a manner contrary to their original intended purpose.

Working in adverse weather conditions should also be considered hazardous. The flooding of traffic routes by rainwater or their icing over sharply elevates the risk of an accident. As preventive measures, it is recommended to avoid working in poor weather conditions, to wear clothing and footwear appropriate for the environment, and to clean traffic routes, machinery, and workstations should they become soiled due to adverse weather. Particular attention is demanded by the process of snow clearance and the securing of pavements and roads against ice during the winter period.

Suggested preventive measures include the regular use of insect repellents by workers and the removal of wasp and hornet nests by specialist companies (should such a nest appear), as well as regular body checks for the prompt removal of ticks if work takes place in areas where they may be present.

Falls of persons are among the most frequently recorded accidents in agricultural work. They accounted for over half of all accidents (52.2%) according to data published by KRUS[29]. Falls from height are the most dangerous, as they can culminate in serious injuries to the limbs, spine, tetraplegia, or even death. Naturally, they can be counteracted to a certain extent, for instance by employing suitable footwear and environmental protections. The probability of this type of accident, however, is substantial.

Hazards with potentially very severe consequences (for example, electrocution, being crushed by a machine, or working in a silo) often exhibit a low probability, but a high level of severity and low detectability, meaning they may occur infrequently, yet their ramifications are highly grave. Such events, despite not occurring on a daily basis, should be treated as critical and require a specialised preventive approach, encompassing the implementation of technical safeguards, conducting training, and monitoring compliance with safety procedures.

Conversely, accidents caused by overtiredness, working without breaks, noise, or working in the heat occur relatively frequently; however, their consequences are generally not severe and feature moderate detectability. Working time regulations specify the maximum permissible working hours, as well as the number and duration of breaks. However, in situations where these regulations are not observed, it is difficult to monitor an employee's state of fatigue.

Overtiredness leads to decreased concentration, which consequently can indirectly result in serious accidents. Therefore, remedial actions should concern not only the elimination of acute technical or chemical hazards but also the continuous improvement of overall working conditions and the implementation of a safety culture in which fatigue, a lack of training, or inadequate lighting are addressed to the same degree as machinery breakdowns.

The conducted analysis allows for the conclusion that the FMEA model is a tool that facilitates accident risk management on a farm. Nevertheless, such an analysis should be further expanded by examining individual production processes, particularly the most hazardous ones, as proposed by Adam Górny[30].

29. Ibidem.
30. A. Górny, *Wykorzystanie FMEA procesu w analizie zdarzeń wypadkowych i doskonaleniu warunków wykonywania pracy* [in:] *Zastosowania Ergonomii. Wybrane kierunki badań ergonomicznych w 2016 roku*, Wrocław, Wydawnictwo Polskiego Towarzystwa Ergonomicznego, 2016, pp. 50–52.

Agricultural tasks should be executed safely and in accordance with regulations. Furthermore, ongoing activities aimed at improving occupational safety should be carried out on the farm. To this end, the FMEA model can be applied, enabling the identification and monitoring of hazardous areas. The development experienced by Polish agriculture in the 20th and 21st centuries cannot be equated solely with the mechanisation and automation of agricultural production. Changes in work organisation are equally vital. Work must not only be efficient but, above all, safe. Individuals managing an enterprise or an agricultural farm ought to employ tools that facilitate the identification and elimination of hazards. Their work should not rely exclusively on assumptions; it should be performed in a standardised manner, enabling the quantification of the results of the implemented changes.

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