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EVALUATING RISK IN THE OPERATION OF AGRICULTURAL MACHINERY BASED ON FARM SIZE

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Purpose: The aim of the study was to identify practical challenges, best practices, and solutions used during the deployment of agricultural machinery depending on the size of the farm
Design/methodology/approach: The method of observation and risk analysis was utilized in the operation of agricultural machinery using the FMEA method to identify potential threats and develop strategies for their mitigation.
Findings: Research conducted on farms has revealed significant issues such as improper maintenance, lack of safety guards, and outdated equipment. To enhance farm safety, it is recommended to adhere to maintenance schedules, replace old machinery with newer models, and use Failure Mode and Effects Analysis (FMEA) to identify and mitigate potential hazards.
Research limitations/implications: Further large-scale research is needed to develop effective strategies for improving farm safety. Implementing structured safety management systems like FMEA is recommended to systematically assess and minimize risks in both individual and large-scale farms.
Practical implications: Implementing recommended measures such as regular inspections and maintenance, replacing or modernizing outdated machinery, using appropriate safety guards, and participating in training sessions will help reduce the risk of machinery failures and the number of accidents.
Originality/value: This article presents new research findings on agricultural machinery safety in individual and large-scale farms, identifying significant issues and proposing specific improvement measures for farmers and agricultural safety experts. These insights help farmers understand risks better and implement safety enhancements when operating machinery.
Keywords: farm safety, agricultural efficiency, agricultural technology.
Category of the paper: Research paper.

1. Introduction

Managing the safety of operating agricultural machinery is a cyclical process that begins with identifying sources of hazards. It involves determining all potential dangers associated with the use of agricultural machinery. Risk assessment is then carried out, which involves identifying how significant the potential hazards are when working with agricultural machinery and the likelihood of their occurrence. Risk assessment helps determine which hazards are most significant and require immediate preventive action. Based on hazard identification and risk assessment, preventive measures are taken to minimize the risk of accidents (Klimkiewicz, 2002).

Currently, there is growing pressure to ensure sustainable development, which also includes the agricultural sector. Sustainable agriculture combines aspects of work safety, production efficiency, and environmental protection (Carvalho et al., 2023; Kuzior et al., 2022). In the European Union, the safety and health of agricultural workers are becoming a priority. In Poland, as in other European countries, agriculture is one of the most dangerous sectors of the economy, and workplace accidents have serious consequences for people's health and lives. These hazards result not only from operating agricultural machinery but also from working with animals and using plant protection products.

The most differentiating factor in equipping farms with mechanization means is undoubtedly their size, measured by the area. The area is the main determinant of production scale (Muzalewski, 2007). Managing the deployment of agricultural machinery and work safety on farms requires considering technical, human, legal, and organizational aspects.

In Poland, small family farms dominate, often with limited financial and technological resources. This makes it difficult to invest in modern machinery and technologies that improve work safety and minimize negative environmental impact. An additional factor increasing the risk is the employment of a larger number of temporary workers, often without proper training. The lack of clear division of duties and supervision, especially in the case of family members' cooperation, can lead to dangerous situations (Rondelli et al., 2018; Moradhaseli et al., 2017).

Compared to family farms, large agricultural enterprises have greater financial and technological resources. Therefore, they can better manage work safety and implement more advanced sustainable development practices. These enterprises often employ trained workers in occupational safety and health and regularly conduct training for employees. The hierarchical organizational structure in large companies allows for better supervision of employees and division of responsibilities, reducing the risk of errors and accidents. Large enterprises use modern precision farming technologies, which allow for production optimization and reduced raw material consumption, positively impacting the environment (Caffaro et al., 2017). An effective agricultural policy should consider the specific needs of smaller farms to

encourage them to implement safer practices and technologies that promote sustainable development.

Among farmers and agricultural entrepreneurs, awareness of the negative effects of workplace accidents is increasing. There is a growing demand for solutions that will improve work safety in agriculture (Zambon et al., 2018). An effective agricultural policy should consider the specific needs of smaller farms to encourage them to implement safer practices and technologies that promote sustainable development. A joint effort by the government, scientific institutions, and representatives of the agricultural industry can contribute to creating better working conditions for farmers and protecting the natural environment.

The aim of the study was to identify practical challenges, best practices, and solutions used during the deployment of agricultural machinery depending on the size of the farm.

2. Management of agricultural machinery operation processes

In the machinery operation process, distinct activities include utilization, servicing, power supply, and management. In individual farmsteads, the primary emphasis is on machinery operation, encompassing maintenance to keep them in operational condition and restoring required functionalities through inspections, repairs, and maintenance (Hu et al., 2019; Sims, Heney, 2017). Main servicing tasks involve periodic technical inspections, serving a preventive purpose and extending the period of trouble-free machinery operation. In large-scale farms, the focus is on machinery management and maintenance to ensure their optimal performance and long-term trouble-free operation (Wolak, 2018).

In individual farms, access to qualified services and specialized equipment is often lacking. The working environment of agricultural machinery is exceptionally demanding and diverse, requiring consideration of many factors during their operation and ensuring work safety (Arana et al., 2010; Lipiński et al., 2021; Ulewicz et al., 2023). These machines are exposed to extreme temperatures, moisture, dust, mud, and chemicals, which can accelerate wear and corrosion of structural elements and adversely affect their reliability. Additionally, these machines operate under high mechanical loads, causing wear of components and increasing the risk of failures. Strong vibrations generated during operation can lead to loosening of connections, cracking of machine parts, and damage to delicate electronic devices.

Tight schedules for field work, high costs of spare parts, and service fees often prompt farmers to attempt repairs themselves, which can lead to errors and deterioration of machinery condition. Servicing agricultural machinery increasingly requires specialized knowledge and skills due to advanced electronic, hydraulic, and mechanical systems (Kim et al., 2016).

Choi et al. (2024) identified insufficient machinery maintenance/management, inappropriate working environment, human factors, and inadequate education/training and lack of regulations or guidelines as the main causes of accidents in agriculture. Machinery degradation during operation poses a safety hazard in agriculture, especially in Polish individual farms, where the average age of machinery is high. The main factors influencing machinery degradation include intensive use, lack of regular maintenance, unfavorable weather conditions, and improper use of machinery. Hazards include breakdowns, fires, accidents, operator injuries, environmental pollution, work stoppages, and financial losses (Lundqvist, Gustafsson, 1992; Turgut et al., 2018).

Research shows that half of the accidents in agriculture occur during machinery operation, and two-thirds of them result from haste, fatigue, and stress. Improper machinery operation is associated with serious consequences stemming from their faulty technical condition. Assessing the technical condition of machinery is a crucial element of managing their operation (Khodabakhshian, 2013).

Active management of the machinery operation process aims to prevent unforeseen breakdowns and ensure their reliable performance. The reliability of agricultural machinery is one of the most critical factors determining the profitability of running a farm, as efficient machines enable timely field work, influencing yields and production quality. Proper management of machinery operation and workplace safety on a farm requires the implementation of several best practices, such as adhering to operating instructions, conducting regular technical inspections and maintenance, using appropriate personal protective equipment, maintaining cleanliness and order in the workplace, and adhering to safety protocols (Irwin, Poots, 2015). Training for farmers in machinery operation and maintenance also impacts machinery operation and workplace safety (Sorensen et al., 2017).

3. Risk analysis in the operation of agricultural machinery using the FMEA method

Risk analysis is a crucial step in the operation of agricultural machinery, aiming to identify, assess, and eliminate potential hazards. Detecting and addressing these hazards can significantly reduce the risk of accidents and injuries on farms.

The Failure Mode and Effects Analysis (FMEA) method enables the identification and analysis of potential defects in agricultural machinery, as well as determining their possible consequences. Additionally, it allows for the identification of actions that can eliminate or minimize the risk of these defects and documenting the entire analysis process (Wolniak, 2018; Wolniak, 2019). The FMEA document requires regular reviews and updates even after the production process begins (Wolniak, Skotnicka, 2011; Wolniak, Skotnicka-Zasadzień, 2014).

Production processes in agriculture are subject to continuous changes due to factors such as seasonality, new technologies, and regulatory changes. Regular FMEA reviews enable the identification and assessment of new potential errors and hazards resulting from these changes.

Risk analysis using FMEA significantly reduces the risk of accidents and injuries in challenging and changing work conditions on farms. An important stage of FMEA is assessing the probability of occurrence, impact, and detectability of each potential failure. These three aspects are assessed using numerical scales, allowing for the calculation of the Risk Priority Number (RPN) for each of them. The RPN is the product of three factors: the probability of failure (P), which determines how often a particular failure may occur; the impact of the failure (S), which determines the consequences for the system; and the detectability of the failure (D), which determines the likelihood of detecting the failure before its consequences occur. After calculating the RPN for all potential failures, the FMEA team can easily identify those requiring immediate intervention. Corrective actions are typically prioritized based on the failures with the highest RPN, as they are the most likely and have the most severe consequences. The final stage of FMEA is monitoring and review. After implementing corrective actions, it is crucial to monitor their effectiveness and regularly review the entire FMEA analysis.

The probability of failure (P) is a scale used to assess the likelihood of machine failure risk.

Criteria for assessing the probability of failure:

1. Very low: The probability of failure under normal operating conditions is highly unlikely. The machine operates steadily and with high reliability.
2. Low: Very little chance of failure. The machine operates correctly, but minor failures may occur due to unforeseen events.
3. Moderately low: There is some probability of problems occurring, but they are sporadic and minor. They may occur due to improper use or unfavorable conditions.
4. Occasional possibility: The risk of failure is moderately high. Possible events several times a year even with proper operation, but they do not affect machine operation.
5. Fairly likely: There is a high probability of a problem occurring that could disrupt machine operations.
6. Likely occurrence several times a year: The risk of failure is very high. Problems may occur frequently and cause serious disruptions in machine operation.
7. Very high probability: Failures may occur frequently, regularly, and may cause significant problems.
8. Very high chance of occurrence: Failures are practically certain to occur frequently under normal conditions. They may cause significant disruptions in machine operation.
9. Almost certain to occur: The event is practically guaranteed to occur under certain conditions.
10. Certain occurrence: Encompasses failures that will definitely occur under normal machine operating conditions.

Potential impact (S) is used to assess the severity of the consequences of a failure.

Criteria for assessing the potential impact:

1. Insignificant: The failure does not cause any damage, injuries, or disruptions to the machine's operation.
2. Minimal: The failure may cause minor damage or injuries that do not require repair or interruption of work.
3. Small: The failure may cause minor damage or injuries, requiring minor repairs and a short interruption of work.
4. Minor: The failure may cause moderate damage or injuries, requiring repairs and a short interruption of work.
5. Moderate: The failure may cause significant disruptions in machine operations or injuries requiring immediate attention and intervention.
6. Significant: The failure may cause serious damage or injuries, requiring repairs and a longer interruption of work.
7. Large: The failure may cause serious damage or injuries, requiring major repairs and a longer interruption of work.
8. Very Large: The failure may cause very serious damage or injuries, requiring immediate shutdown of the machine and extensive repairs, and may have a significant impact on production or the environment.
9. Critical: The failure may cause extremely serious harm to human health and safety, as well as very large environmental pollution. Machines require immediate shutdown.
10. Catastrophic: The failure may cause catastrophic damage or injuries, as well as permanent environmental pollution. Machines require immediate shutdown and serious repairs. Catastrophic impact on production and the environment.

Detection difficulty (D) is used to assess the ease of detecting a potential failure before it occurs.

Criteria for assessing the detection difficulty:

1. Immediate detection ease: Failure is quick to locate and very easy to detect for anyone.
2. Very high detection ease: Detecting issues is possible but may require some effort. Failure is easily detectable by individuals with basic machine operation training.
3. High detection ease: Failure is detectable by experienced individuals familiar with the machine.
4. Moderate detection difficulty: Failure requires some effort or the use of specialized tools for detection.
5. Moderately challenging to detect: Failure requires more specialized knowledge or tools, which may be less common.
6. Difficult to detect: Failure is challenging to detect and requires significant technical knowledge and specialized diagnostic tools.

7. Very difficult to detect: Failure is very difficult to detect and requires advanced diagnostics, advanced skills, and specialized tools.
8. Extremely difficult to detect before failure: Failure is practically impossible to detect before it occurs and can only be detected through monitoring or data analysis.
9. Practically impossible to detect before failure: Failure is practically impossible to detect before it occurs and may be detected under highly unlikely circumstances.
10. Certain to be overlooked before failure: Failure is certain to occur, with no warning signs or possibility of detection before it occurs.

4. Results and discussion

Comparison of managing the process of safe operation of agricultural machinery in individual and industrial farms reveals some similarities and significant differences. Training, regular inspections, maintenance, adapting machinery to work conditions, compliance with regulations and safety standards, and risk management are elements of managing the process of safe operation of machinery on farms. These elements form a comprehensive management system aimed at ensuring maximum safety and efficiency in working with agricultural machinery.

The hazard analysis revealed that technical, organizational, and economic factors have a significant impact on the safety of working with agricultural machinery and tractors. A study conducted on individual and multi-area farms identified several important practices related to managing safety and the workflow of agricultural machinery operations. A common problem identified in individual farms was inadequate maintenance of machinery, which often led to increased risk of breakdowns and accidents. Additionally, in many cases, machines lacked necessary safety guards, which are important for protecting workers from potential injuries. The absence of these safeguards posed a serious threat to the health and lives of workers. In contrast to individual farms, such situations were sporadic in multi-area farms, mainly due to better work organization and higher investments in machinery maintenance. Multi-area farms have a more coordinated maintenance system, which includes regular inspections and servicing of machines. Additionally, employees in multi-area farms are usually more aware of safety and hygiene regulations, leading to strict compliance. This also includes the use of appropriate guards and safety features on machines, which are crucial for protecting the health and lives of workers. Multi-area farms more effectively minimize the risk of breakdowns and accidents associated with the operation of agricultural machinery due to a more professional infrastructure and higher safety standards.

Training and education for agricultural machinery operators vary depending on the scale of operations. In individual farms, the approach to training was typically less formal. Experienced workers or farm owners would instruct new operators on-site, demonstrating basic machine operation principles, safety regulations, and associated hazards. In contrast, multi-area farms had more formal training programs. These programs were conducted by qualified personnel with relevant knowledge and experience. They typically covered machine operation and maintenance principles, workplace safety and hygiene, first aid, and environmental protection issues. According to Kapela and Jabłonki (2008), a significant portion of individual farmers are willing to participate in training on agricultural machinery operation. Up to 42.5% of individual farmers are willing to dedicate up to 10 hours to training. The high willingness of farmers to participate in training indicates the existing demand for such services.

In agricultural farms, the approach to machinery inspection and maintenance varied depending on the scale of operations. In individual farms, farmers often conducted inspections and maintenance of agricultural machinery themselves or used the services of local mechanics. In contrast, on multi-area farms, there were formalized inspection and maintenance procedures in place. Qualified mechanics regularly checked the condition of the machines and replaced worn-out parts. They had access to specialized diagnostic equipment, allowing for more precise examination and diagnosis of faults. Regardless of the scale of operations, all farmers are required to carry out periodic technical inspections of sprayers. These inspections, conducted by authorized entities, confirm the efficiency of devices for applying plant protection products. It is also worth mentioning that some insurance policies may require combine harvesters to be inspected by an external company before insurance is granted. Improper maintenance of agricultural machinery, delaying necessary servicing activities, and replacing original consumables with cheaper alternatives are the main causes of unexpected breakdowns that can endanger workers (Jósko, Kołodziejski, 2008).

In individual farms, older agricultural machinery was often used, which did not always meet current safety standards. This was due to financial constraints. As a result, the risk of breakdowns and accidents was higher. However, in multi-area farms, this problem was rare because owners invested in newer agricultural machinery, which was more reliable and met current safety standards. Additionally, they conducted regular maintenance of the machinery, which allowed them to keep it in good working condition and minimize the risk of breakdowns and accidents. Moreover, modern machinery was covered by manufacturer warranties, guaranteeing access to service and repairs if needed. The farm also had a schedule for regular maintenance and inspections of agricultural machinery. This allows for the detection and repair of faults at an early stage, preventing breakdowns and extending the lifespan of the machinery.

The process of adapting agricultural machinery to the specific needs of a farm varied depending on its size. In individual farms, the adjustment of machinery often occurred intuitively. Farmers relied on their own experience or the experience of their neighbors, adjusting the parameters of the machinery to current needs. In contrast, in multi-area farms,

a detailed analysis of the farm's specifics and the type of work to be performed was conducted before purchasing machinery. Based on this analysis, equipment with appropriate parameters and functionalities was selected. Additionally, in multi-area farms, there was the possibility of ordering machinery with special configurations or additional safety systems.

While multi-area farms typically adhere to more formal and comprehensive safety management systems for agricultural machinery, regulations regarding safety and hygiene during the operation of agricultural machinery apply to all farms, including individual ones (Regulation of the Minister of Agriculture and Rural Development of February 14, 2024), on safety and hygiene at work in the operation of tractors, machinery, tools, and technical devices used in agriculture (Official Gazette 2024, item 228). In individual farms, where farmers usually work alone or with family members, there is no obligation to conduct external safety inspections. However, this does not mean that these farmers are exempt from complying with regulations. The responsibility for safety lies solely with the farmer.

The greatest differences between individual farms and industrial-scale ones lie in risk management. In individual farms, farmers rely on their experience and intuition to identify hazards, and preventive actions are taken ad hoc, without a formal process. In contrast, industrial-scale farms employ formalized procedures, precisely identifying and managing risks by implementing accident and malfunction prevention systems. Marks-Bielska et al. (2018) demonstrated that the vast majority of individuals working on farms (80%) were unaware of the types of risks they are exposed to.

The findings suggest that improving workplace safety with agricultural machinery on individual farms requires the implementation of formal training programs, easy access to safety information, and financial support for the purchase of modern machinery. Encouraging farmers to collaborate and exchange experiences can increase awareness and improve safety practices.

In large-scale farms, it's essential to maintain and update training programs, invest in modern machinery and technologies, and implement monitoring and diagnostic systems. Regular inspections and maintenance should be conducted by qualified mechanics. Risk management systems need to be regularly reviewed and updated to ensure effective protection for workers.

In addition to the above-mentioned actions, implementing a structured safety management system, such as Failure Modes and Effects Analysis (FMEA), could significantly enhance safety when working with agricultural machinery in both individual and large-scale farms.

The application of the Failure Mode and Effects Analysis (FMEA) method in assessing risks associated with the safety of agricultural machinery on farms has yielded critical insights into potential hazards and necessary corrective actions. The results summarized in tables 1 and 2 of the FMEA illustrate various threats, their calculated Risk Priority Number (RPN), and suggested interventions. A threshold RPN of 120 was established to prioritize issues requiring immediate attention.

Table 1.
Determining the level of risk of hazards in the safe operation of agricultural machinery in individual farms using the FMEA method

Hazard ID	Description of hazard	Probability of failure (1-10)	Potential impact (1-10)	Detection difficulty (1-10)	RPN
Z1	Unshielded moving parts	8	9	4	288
Z2	Use of outdated tractors	6	7	6	252
Z3	High machine workload	6	6	6	216
Z4	Lack of regular maintenance	8	9	4	288
Z5	Operation in harsh conditions	4	8	8	256
Z6	Ignoring safety protocols	10	8	4	320
Z7	Inadequate operator training	6	6	6	216
Z8	Use of non-standard parts	6	8	8	384
Z9	Poor electrical insulation	8	10	4	320
Z10	Overloading of machines	8	6	6	288

Source: Own research.

Table 2.
Determining the level of risk of hazards in the safe operation of agricultural machinery in large-scale farms using the FMEA method

Hazard ID	Description of hazard	Probability of failure (1-10)	Potential impact (1-10)	Detection difficulty (1-10)	RPN
Z1	Unshielded moving parts	4	9	3	108
Z2	Use of outdated tractors	3	7	4	84
Z3	High machine workload	6	6	5	180
Z4	Lack of regular maintenance	3	9	4	108
Z5	Operation in harsh conditions	4	8	8	256
Z6	Ignoring safety protocols	4	8	3	96
Z7	Inadequate operator training	2	6	6	72
Z8	Use of non-standard parts	4	8	6	192
Z9	Poor electrical insulation	4	10	4	160
Z10	Overloading of machines	6	6	4	144

Source: Own research.

In this analysis, a permissible threshold value of the Risk Priority Number (RPN) was set at 160. This means that any threats with a resulting score exceeding this value are classified as highly risky and require immediate as well as strategic corrective actions to effectively mitigate potential hazards. The analysis of individual threats is as follows:

High-Risk Threats (RPN > 160):

Z1: Unshielded moving parts (RPN = 288)

In individual farms, this threat poses significant risks due to the potential for serious injuries such as cuts, amputations, or even fatal accidents. The immediate installation of protective guards on all machines with moving parts is absolutely necessary. Additionally, regular safety checks to verify the integrity and functionality of these guards are crucial for maintaining a safe work environment.

Z2: Use of outdated tractors (RPN = 252)

In individual farms, the operation of outdated tractors can lead to increased failure rates, posing risks of mechanical failures resulting in operator injuries due to sudden stops or

component malfunctions. Strategies to minimize this risk include upgrading to newer models compliant with current safety standards, increasing the frequency of maintenance inspections, and implementing a rigorous training program to educate operators about potential hazards associated with operating older equipment.

Z3 to Z10 (RPN from 216 to 384)

In individual farms, a significant level of threats is observed, such as excessive machine loading or poor electrical insulation, which exceed the permissible RPN level. This situation indicates systemic issues with machine maintenance, operational standards, and compliance with safety regulations. The implementation of a comprehensive set of corrective actions is necessary to improve this situation.

In multi-area farms, the only threat in this group is working conditions that may lead to excessive machine wear, increased risk of failures, and hazardous situations for operators. This suggests the existence of a more rigorous approach to safety, characterized by better risk control and more coordinated efforts to ensure safety.

Z3 (RPN 180) and Z4 (RPN 192)

Threat Z3 pertains to high machine loading, which can lead to excessive wear and increased risk of failures. Meanwhile, threat Z8 is related to the use of non-compliant parts, which may cause machine malfunctions and increase the risk of accidents. In individual farms, all threats were in higher risk groups, suggesting greater risks associated with machine operation and potentially lower safety and maintenance standards. Jósko and Kołodziejski (2008) also highlighted this issue, emphasizing that the condition of agricultural vehicles and machinery during their operation depends primarily on the proper selection of operational materials, the conditions of use, and the correct execution of maintenance activities. Failure to adhere to maintenance schedules properly leads to excessive wear of components, increased likelihood of failures, and consequently, accidents.

In multi-area farms, the remaining threats fall into the minimal risk group (Z1, Z2, Z4, Z6, Z7), which requires monitoring, and the significant risk group, which requires assessment and corrective actions (Z10).

Research conducted in individual farms reveals widespread issues with inadequate machine maintenance and a lack of necessary safety guards. These neglects lead to increased risks of equipment failures and accidents. The analysis by Pompeii et al. (2015) and our research indicate that improper use of equipment and the use of devices without appropriate safeguards are common in agriculture. Pompeii et al. (2015) found that 64.8% of tractors in agricultural holdings were defective. Similarly, Juliszewski (2007) identified that faulty machinery and poor technical condition (e.g., lack of shields on moving parts, defective telescopic PTO shafts) are among the main causes of agricultural accidents. Pawlak and Nowakowicz-Dębek (2015) demonstrated that one of the causes of agricultural accidents is a lack of knowledge about occupational health and safety (OHS) principles and reluctance to familiarize oneself with safety instructions for machine and equipment operation. Kogler et al. (2015) found that the

majority of agricultural accidents in Austria resulted from contact with machinery (55%) and loss of control over machinery (73%) during its operation (60%) and during harvest-related activities (63%). According to the research by Ichihara et al. (2019), machinery-related injuries (12.2%) were also the most common type of agricultural accidents in Japan. Another significant risk in individual farms is the improper use of machinery and equipment. Additionally, there is a clear correlation between the use of older machines and the frequency of equipment breakdowns, highlighting the risks associated with outdated agricultural tools. These results are consistent with the research of other authors, who also emphasize the higher risk of accidents in individual farms compared to multi-area farms. As Kuta and Cież (2013) point out, individual farms often have fewer opportunities to invest in new equipment and technology. Modern agricultural machinery can significantly improve the level of work safety.

In multi-area farms, only one threat in this category was identified, namely, working conditions that may lead to excessive machine wear, increased risk of failures, and hazardous situations for operators.

Compared to individual farms, multi-area farms stand out with characteristics such as fewer hazards and a more rigorous approach to safety. There is a lower number of risks related to machine maintenance, operational standards, and compliance with safety regulations, likely stemming from a stricter safety approach, which entails better risk control and more coordinated actions to ensure worker safety. As McNamara et al. (2021) report, in large agricultural farms, training in occupational safety and health increases employee awareness and contributes to reducing the number of accidents. However, it's essential to note that even in multi-area farms, it's not possible to completely eliminate the risk associated with working in unsuitable conditions. Therefore, despite generally better safety control in these farms, ongoing monitoring and risk management are still necessary to ensure full worker safety.

Ensuring safe working conditions in workshops and fields is essential for protecting the health and lives of farmers. This includes proper workshop equipment, adapting repair areas to safety requirements, and providing farmers with appropriate personal protective equipment.

To improve safety in agriculture, structured safety management systems such as FMEA should be implemented, allowing for systematic assessment and minimization of risks associated with machinery operation.

5. Conclusion

Technical, organizational, and economic factors have a significant impact on the safety of working with machinery on individual farms. In the surveyed individual farms, the most common irregularities included the lack of appropriate guards and protections, poor technical condition of machinery, and errors in operation. The aging of machinery and limited access to

servicing made it difficult for farmers to maintain them in proper technical condition. Machinery repairs often took place in unfavorable conditions, increasing the risk of accidents. Irregular inspections and maintenance led to breakdowns and damage.

In the multi-area farm, there is observed a lower number of hazards due to a rigorous approach to safety. Effective risk control methods are implemented, and safety procedures are regularly updated. Training programs for employees are also conducted. Support programs are utilized, and modern technologies are promoted. However, monitoring and risk management are still necessary to ensure full safety for the workers.

It is also crucial to raise awareness about the hazards associated with using old agricultural machinery and actively promote their replacement with new ones that meet current safety standards. The technical condition of agricultural machinery plays a vital role in work safety. Regular inspections and maintenance according to the manufacturer's recommendations are necessary to keep the machines in good technical condition. During repairs and maintenance of agricultural machinery, it is important to use only original spare parts. This ensures not only the durability of the machines but, above all, guarantees their safety during operation. Used agricultural equipment should have a visible CE marking and a declaration of conformity with the currently applicable regulations.

To improve workplace safety in both individual farms and large-scale farms, implementing structured safety management systems such as FMEA is recommended. These systems enable systematic assessment and minimization of risks associated with machinery operation.

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