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An Economic Perspective on Determinants of Work-Related Accidents in Poland's Agricultural Sector

Abstract

Aim of the work: Work-related accidents are a significant socio-economic problem. This article reviewed pertinent literature and the research material analysed. The aim of this study was to analyse accidents in agriculture with respect to the selected economic theories and the key factors determining their occurrence.

Research method: The literature review was conducted as a narrative supported by bibliometric analysis. Publications indexed in the Web of Science and Scopus databases, supplemented by Google Scholar searches, were analysed to identify the dominant research trends and methodological approaches to occupational accidents in agriculture. In the empirical part of the study, secondary data obtained from the Poland's Agricultural Social Insurance Fund (ASIF; Polish: KRUS) were analysed to examine the structure of occupational accidents in Polish agriculture over the period 2014–2024. Study results were generated through the use of time-trend analysis which enabled better understanding of causal changes in agricultural workplace accidents.

Key results: The results indicate that the number of accidents related to machine and equipment servicing and use are rising; accidents related to animal husbandry were stable but high.

Main conclusions: The fact that agricultural accidents caused by human error is the highest and rising is disturbing. The comparison of Poland's agricultural accidents resulting from human error between 2014 and 2024 has risen by 33% and were caused by, among

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others, inappropriate conduct by farmers and/or employees. Analyses of long time series may improve understanding the conditions for said accidents in agriculture and becoming valuable in supplementing existing research.

Keywords: risk economy, accidents, agriculture, human resources.

1. Introduction

Besides a loss of health, physical suffering and full employment ability (disability benefits for incapacitation do not fully compensate losses), a farmer injured through a workplace accident loses social status, experiences a loss of personal ambition, loss of personal and social advance (Zielińska, 2025b, p. 161). The number of work-related accidents in Poland agriculture sector rose by 10,000 in 2024 and continues to be significantly developing in the wrong direction, indicating that challenges in the areas of, among others, education, technology and social capital continue to exist and that there is much room for improvement in prevention in these areas (Zielińska, 2025a, p. 219). In spite of technological progress, machinery modernisation, and development of regulations with regard to occupational health and safety, the level of accident risk in agriculture is significantly higher than the average for all other economic sectors. The accident indicator, i.e. number of injured per 1000 insured in Poland's agriculture sector, was 7.8 in 2024, in spite of rising awareness of regulations and principles of occupational health and safety in agriculture. This may indicate worsening workplace conditions in agriculture (Zielińska, 2025b, p. 164). The specificity of agricultural work – including seasonality, work conditions dictated by variable environmental conditions, inability to control external conditions, family participation (including children), as well as the domination of small fragmented farms – compromises effective work place safety management. Demanding workplace competence, uncertainty of economics and weather, long working hours and stress raise risk factors for farmer accidents and their employees (Będzik, Gołąb, Będzik, 2025).

Work-related accidents in agriculture generate serious socio-economic costs, which not only include medical expenses, but also long-term effects in the forms of human resource loss, lower economic productivity, and burdening the social security system. With this in mind, the issues with occupational safety in agriculture are an important interdisciplinary area of research linking economics, medicine and technical science.

2. Research Objective and Methodology

The aim of this study was to analyse accidents in agriculture with respect to the selected economic theories and the key factors determining their occurrence.

To address the study objective, the following research questions were formulated:

RQ1. To what extent do selected economic theories explain the patterns and determinants of occupational accidents in the agricultural sector?

RQ2. What are the dominant research directions in the contemporary scientific literature on occupational accidents in agriculture?

RQ3. How have id economic, organisational, institutional, and human behavioural factors influenced the occurrence and structure of occupational accidents in Polish agriculture during the period 2014–2024?

Achieving the research objective required the application of research methods commonly used in the fields of economics and the social sciences. These methods enabled both the identification of the theoretical determinants of occupational safety in agriculture and an empirical analysis of occupational accidents in the agricultural sector.

The literature review was conducted using a bibliometric analysis approach to identify the main research trends concerning occupational accidents in agriculture. Publications were retrieved from internationally recognised scientific databases, including Web of Science and Scopus. In addition, complementary searches were performed using Google Scholar to identify relevant publications not indexed in the major citation databases, particularly those concerning Polish agricultural safety research.

The literature search was conducted using combinations of the following keywords: ‘occupational accidents in agriculture’, ‘agricultural safety’, ‘farm injuries’, ‘occupational health’, ‘agricultural economics’, ‘safety culture’, ‘machine safety’, ‘risk factors’, and ‘accident prediction’. The review covered publications published between 1995 and 2025. The selection process included peer-reviewed journal articles, conference papers or theoretical contributions related to occupational accidents in agriculture. The publications were subsequently classified according to their dominant research perspective (medical, forensic, engineering, legal, economic, statistical-econometric, behavioural, and artificial intelligence/predictive analytics), enabling the identification of the principal research streams presented in Table 1.

The procedure applied represents a narrative literature review supported by bibliometric analysis. Its purpose was to identify the dominant methodological approaches and emerging research trends in studies on occupational accidents in agriculture, rather than to conduct a formal systematic literature review.

In the empirical part of the study, a statistical analysis of secondary data was conducted. The research material comprised data on occupational accidents in Polish agriculture covering the period 2014–2024, obtained from the Agricultural Social Insurance Fund (ASIF; Polish: KRUS). The analysis focused on the number and structure of occupational accidents with regard to the type of work performed, the machinery and equipment involved, the day of the week, and the time of day when the accidents occurred.

A comparative analysis was employed to identify changes occurring over the study period. This approach enabled the assessment of trends and dynamics in the structure of occupational accidents, the identification of the predominant causes of accidents, and the determination of factors affecting the level of occupational risk in agricultural holdings. In addition, a structural analysis was performed to examine the distribution of individual categories of accidents within the overall number of reported cases. This analysis made it possible to assess changes in the significance of human factors, the proportion of accidents associated with the operation of agricultural machinery and equipment, and the periods of the highest accident risk according to the day of the week and the time of day.

The results were interpreted using descriptive analysis and inductive reasoning. These methods facilitated the integration of the statistical findings with the assumptions of selected economic theories, particularly human capital theory, the economics of risk, market failure theory, and institutional economics. This approach made it possible to explain the mechanisms influencing occupational safety and to assess the role of economic, organisational, and institutional factors in the occurrence of occupational accidents in agriculture.

The combination of these research methods provided a comprehensive assessment of occupational accidents in agriculture by integrating theoretical considerations with empirical evidence. It also enabled the identification of changes in the structure of occupational accidents between 2014 and 2024 and the evaluation of their economic, organisational, and institutional determinants.

The first phase of this article reviews economic theories and current empirical studies regarding workplace accidents in agriculture. Secondly, taking advantage of unpublished ASIF data, a configuration analysis of agricultural workplace accidents in Poland was generated and key determinants of said accidents established.

3. Approaching the Issue of Agricultural Accidents within Selected Economic Theories

The analysis of workplace accidents in agriculture may be framed in a number of economic doctrines. First, the theory of human capital has primary significance

where health, experience and qualification to work are one of the basic factors for agricultural productivity (Becker, 1964). Agricultural accidents depreciate human capital which negatively impacts economic effectiveness and long-term development of farms – especially family farms. Work is inextricably tied to human existence; it requires not only practical skills, but also theoretical information regarding the occupation performed (Zielińska, 2025a, p. 209). In contrast to various other economic sectors, the work of a farmer – and members of the family – invariably represent the primary production factor (Nowak, Gradziuk, Jarosz-Angowska, 2025). Injury or total inability to work of one household member may directly endanger the functioning of an entire farm. From an economic perspective, consequences of accidents not only include medical expenses or rehabilitation, but also lost income, loss of productivity and necessity of reorganising said work (Leigh, 2011). Accidents engender permanent or temporary productivity loss of a farm, lowered effectiveness of utilising remaining productive factors, necessity of hiring temporary employees or reducing production scale. In terms of long-term periods, high accident rates lower amortisation of human capital investments, discouraging undertaking work in the agricultural sector which in turn deepens demographic and structural problems of the sector.

Secondly, the issue of agricultural workplace accidents may be interpreted from the perspective of the economics of risk and uncertainty. Farmers undertake decisions regarding productivity with limited information and environmental variability, frequently accepting higher risks hoping to reduce costs and/or maximising work returns. Studies indicate that many farmers base their decisions on multi-year experience, overestimate their skills, and underestimate the potential for accidents (Kahneman, Slovic, Tversky, 1982). Time urgency during the most intensive work in the fields are conducive to producing short-cuts and undertaking risky behaviour. In effect, a rational individual – attempting to maximise current income – is in conflict with long-term and social rationality i.e. minimalisation of accident costs (Hardaker et al., 2015). Farmers function in an environment of uncertainty: weather, market prices or agricultural policy, where occupational accident risk is marginalised. Risk economics indicate that in such conditions, decisions regarding safety are dictated by subjective risk assessment.

Thirdly, the theory of market failure can also be applied to this issue. Agricultural accidents generate external costs, which are not completely internalised by agricultural producers, justifying state intervention in the forms of legal regulation, insurance systems and prevention programmes. The most important market-failure mechanisms are:

- external costs (financing medical treatment, rehabilitation, disability benefits);

- information asymmetry (lack of full knowledge regarding risk and effective preventive measures);
- imperfections of the insurance market especially in regard to small farms.

Farmers are not always fully informed about risk and potential accident costs are not fully taken into account in economic decisions. Even though considered essential from the social perspective, insurance systems can additionally weaken motivation for work safety investment, causing a rift between individual and social interests.

To complete the above perspectives to this issue is institutional economics, emphasising legal frameworks, institutions – such as ASIF – and the harmonisation with European Union (EU) regulations in shaping the level of occupational safety in agriculture. The harmonisation of EU provisions – especially those regarding machinery and work organisation safety – has contributed to the reduction of agricultural workplace accidents, as confirmed by empirical studies in Poland and other European states. Concurrently, the effectiveness of the regulations depends on adjusting said regulations to the functioning reality of given farms. In regions of fragmented agrarian structure, formal provisions frequently compete with consolidated cultural norms and economic limits (Wilkin, 2016). Thus legal regulation is insufficient; it must be aided by financial support, consultancy and educational efforts.

The economic analysis of workplace accidents in agriculture indicates that they are not simply technical or organisational problems; they are the result of complex interactions between economic stimuli, decision behaviour and institutional frameworks. Effective accident-prevention policy requires a systemic approach – integrating economic, regulatory and educational instruments.

4. Agricultural Workplace Accidents in Review

Studies examining agricultural workplace accidents in Poland and Europe are characterised by methodological and institutional diversity. Key for those in Poland are those performed by ASIF, the Statistics Poland (Polish: GUS), State Labour Inspection (SLI; Polish: PIP), and academic centres – especially forensic medical units and public health. Regarding European studies, those by Eurostat (European Statistics on Accidents at Work – ESAW) dominate, supported by specialist accident databases such as the Analysis, Research and Information on Accidents (ARIA) or the Major Accident Reporting System (eMARS).

Table 1 presents studies pertaining to agricultural accidents qualifying into different analytical category contexts, such as medical, technical engineering, institutional law, or economics. Modern analytical models are gaining greater recognition

e.g. econometric, GIS spatial analyses, and machine-learning techniques, used for identifying increased risk and accident prediction. Authors stress lack of essential data including the issue of underestimated accidents occurring at small farms and insufficiency of comprehensive international comparisons.

Table 1. Studies of agricultural accidents according to analytical categories

Tabela 1. Badania w zakresie wypadków w rolnictwie według nurtów analitycznych

Category trend (authors, year)	Study questions	Methods	Determinations
Medical (Public Health, Injuries, Health System Liability) (Gorucu, Michael, Chege, 2022; Kjestveit, Aas, Holte, 2021)	What is the frequency of injuries? What are the health consequences, classification, risk group (age, sex), seasonality, and injury severity?	- studies based on hospital data and hospital registry; - descriptive statistics, and regressive models for risk factor identification	- predominant injuries connected with machinery and hard physical labour; - primary problem with non-fatal injury trauma treatment; - comparison difficulty between countries due to differing registration systems
Forensic medicine and studies of fatal accidents (mechanisms of death, event reconstruction) (Facchinetti et al., 2021; Ketenci, 2020; Özdeş, Berber, Çelik, 2011)	What are the direct causes of death? What is the injury mechanism and the 'accident scenarios'?	- analysis of fatal events; - event reconstruction and injury-mechanism analysis; - work on police evidence, forensic medicine, event records	- a high proportion of machine-related events (including tractors) and mechanical energy; - usefulness of event reconstruction for prevention design (e.g. identification of critical moments in work processes)
Technical engineering and ergonomics (machine safety, safety shields, ROPS, design) (Micheletti Cremasco et al., 2020; Reynolds, Groves, 2000; Rondelli, Casazza, Martelli, 2018)	How do machine features impact risk? What technical solutions will reduce accidents (safety shields, switches, protective construction)?	- machine safety audits and compliance assessment; - ergonomic work-station study; - Failure Modes and Effects Analysis (FMEA), cause analysis (dependent of vocation); - study of protective assemblies (.e.g. Rollover Protection Systems [ROPS] regarding tractors)	technical safety measures and construction standards are key, but their effectiveness depends on use

Table 1. – cont.

Tabela 1. – cd.

Category trend (authors, year)	Study questions	Methods	Determinations
Institutional law (EU Regulations, Compatibility, Legal Enforcement) (Zielińska, Bajdur, 2020; Żywicka, Choina, Jarosz, 2021)	How do law and institutions influence safety? What are the effects of law compatibility of EU regulations and their implementation by states?	• institutional and legal analysis; • assessment of regulation impact (frequency quality assessment or frequency in accident data); • international comparison of directive implementation	• EU compatibility (e.g. machine safety) relates to lowered accident tendency, but the effects are spatially uneven and depend on socio-economic conditions; • regulations alone are not sufficient – oversight, implementation and user training are key
Economics (human capital, accident liability, modernisation, stimuli) (Adhikari, Wilson, Rautiainen, 2024; Zielińska, 2025a; Żywicka, Choina, Jarosz, 2021)	How do accidents impact productivity and farm development? What economic factors (income, investments, agrarian structures) co-occur with risk?	• trend analyses and accident prognosis (regarding agriculture economics), • ergonomic models (time series/panel data), • accident interpretation as loss of human capital and economic activity risk.	• reported drop in accident tendency coupled with modernisation, regulations and preventative efforts, • human error, regional differences and small-farm limits continue to be significant
Statistical-econometric (time series, prognosis) (Bailer, Reed, Stayner, 1997; Wróbel, 2018; Zielińska, 2025a; 2025b)	How are trends shaping up? Can accident numbers be anticipated? How can risk factors be tested?	• naive method version of increase without change, Holt's model and trend function; • time-series models (ARIMA/SARIMA); • regression; • panel analysis; • prediction validation (e.g. sample division, models comparison)	• transition from descriptive statistics to the prediction approach; • growing role of quantitative modelling in prevention policy (e.g. identification of high risk phases)
Behavioural and 'safety culture' (human factors, behaviour, training) (Bai et al., 2023; Coman et al., 2020; Surendran et al., 2025; Zielińska, 2017)	Why do users undertake behaviour risk? How does training work? What kinds of intervention are effective?	• surveys, interviews, quality studies; • analyses of event scenarios; • educational programme evaluations	• operator error remains key factor; training alone does not give a lasting effect without technical and institutional support; • need for multi-element intervention (technique + regulation + behaviour + implementation)

Table 1. – cont.

Tabela 1. – cd.

Category trend (authors, year)	Study questions	Methods	Determinations
ML/AI and predictive analytics (risk prediction, data merging, automation) (Davoudi Kakhki, Freeman, Mosher, 2019; Mermer et al., 2026; Zielińska, Bajdur, 2019a; 2019b)	Can algorithm learning improve accident prediction and risk identification? How can ML with GIS be merged with administrative data?	• classifiers and prediction models (e.g. random forests, SVM, neuron networks – depending on studies); • learning from multi-source data; • hybrid approach (ML + GIS + classic models)	• trend rising but its development is limited by quality and data consistency; • literature points to need for pilot programmes and regulation framework for AI regarding occupational health and safety

Source: own study.
Źródło: opracowanie własne.

The research conducted within the framework of this article contributes to the existing literature on occupational safety in agriculture by offering a novel perspective that integrates economic theory with an empirical analysis of the structure of occupational accidents in Poland. Previous research on occupational accidents in agriculture has focused predominantly on technical, medical, ergonomic, and legal aspects, whereas comparatively little attention has been paid to interpreting this phenomenon through the lens of economic theory.

The scientific novelty of this study lies primarily in the application of human capital theory, the economics of risk and uncertainty, market failure theory, and institutional economics as a coherent theoretical framework for interpreting empirical findings on occupational accidents in agriculture. This approach enables the phenomenon to be explained not only in terms of technical factors but also with reference to the economic, organisational, institutional, and behavioural determinants that influence farmers’ decision-making processes.

The study addresses several important research gaps. First, it responds to the limited number of studies integrating economic theories of farmers’ behaviour with empirical analyses of occupational accident data. Second, it provides a comprehensive assessment of long-term changes in the structure of occupational accidents over the period 2014–2024. Third, it demonstrates the importance of incorporating organisational and behavioural factors alongside the technical determinants that have traditionally dominated research on occupational safety in agriculture.

By combining theoretical considerations with empirical evidence, the study offers a broader understanding of the determinants of occupational accidents in

agriculture and highlights the role of economic mechanisms in shaping occupational safety. The findings contribute to the development of a multidisciplinary approach to agricultural safety and may provide a useful basis for designing more effective preventive policies and institutional interventions aimed at reducing occupational accident risks in the agricultural sector.

5. Research Results

The incidence of agricultural workplace accidents in Poland is systematically falling – from close to 20,000 events in 2014, to 9,105 in 2024. In Poland, between 2014 and 2024, the average drop in agricultural accidents has been 8% i.e. 1,122 events, which should be generally assessed as positive (Zielińska, 2025a, p. 213). The past decade has shown a drop in agricultural accidents of 54.7%, and a drop in those insured by 31.3%. In the conversion of per 1,000 insured, was a drop of 33.4%. This tendency indicates improvement in work safety in Poland's agriculture, which can be credited to, among others, technological and organisational modernisation of the sector (Zielińska, 2025a, p. 215).

The assessment of agricultural accidents classifications, based on type of work done, is analysed in 17 types of work, i.e. travelling to and from location without load; manual transport (in hand or on shoulder, etc.); transport by wheelbarrow, cart, etc.; mechanical transport of livestock, agricultural produce and production means; work at height (in trees, stacks, heaps, attics, lofts, scaffolding, etc.); work in excavations, tanks, depressions; farm clean up; household clean up; maintenance; renovation; construction and demolition of buildings and objects; servicing and use of agricultural machines and equipment (including aggregation and regulation, fieldwork, planting and pasture work); agricultural machine and device renovation and repair; wood harvesting and processing (fuel preparation, construction material, etc.); animal feed preparation (steaming, shredding, etc.); animal husbandry and care (feeding, milking, health treatments, herding, etc.); manual formwork, including hand tools (rakes, hoes, pitchforks, knives, shears, etc.); processing farm products (fruit, vegetables, meat, milk, grain, etc.); administrative tasks, supply purchases, etc. and "other" categories (not classified into the above groups).

Five types of activities (Figure 1) classified as the majority of workplace accidents in the agricultural sector in 2024, representing 60 to 71% of all accidents:

- travelling to and from location without load – 20% of events;
- manual transport – in hand or on shoulder, etc. – 13% of events;
- work at height (in trees, stacks, heaps, attics, lofts, scaffolding, etc.) – 7% of events;
- servicing and use of agricultural machines and equipment (including aggregation and regulation, fieldwork, planting and pasture work) – 12% of events; and

- animal husbandry and care (feeding, milking, health treatments, herding, etc.) – 19% of events.

Disturbingly visible in Figure 1 is the rising trend in agricultural accident frequency for the study period – 7 percentage points for travelling to and from work sites without loads (a rise from 13% in 2014, to 20% in 2024), and a 5% rise for servicing and use of agricultural machines and equipment (a rise from 7% in 2014, to 12% in 2024). It is worth noting that the accident incidence for animal husbandry for the study period remains steady yet high – approximately 19%.

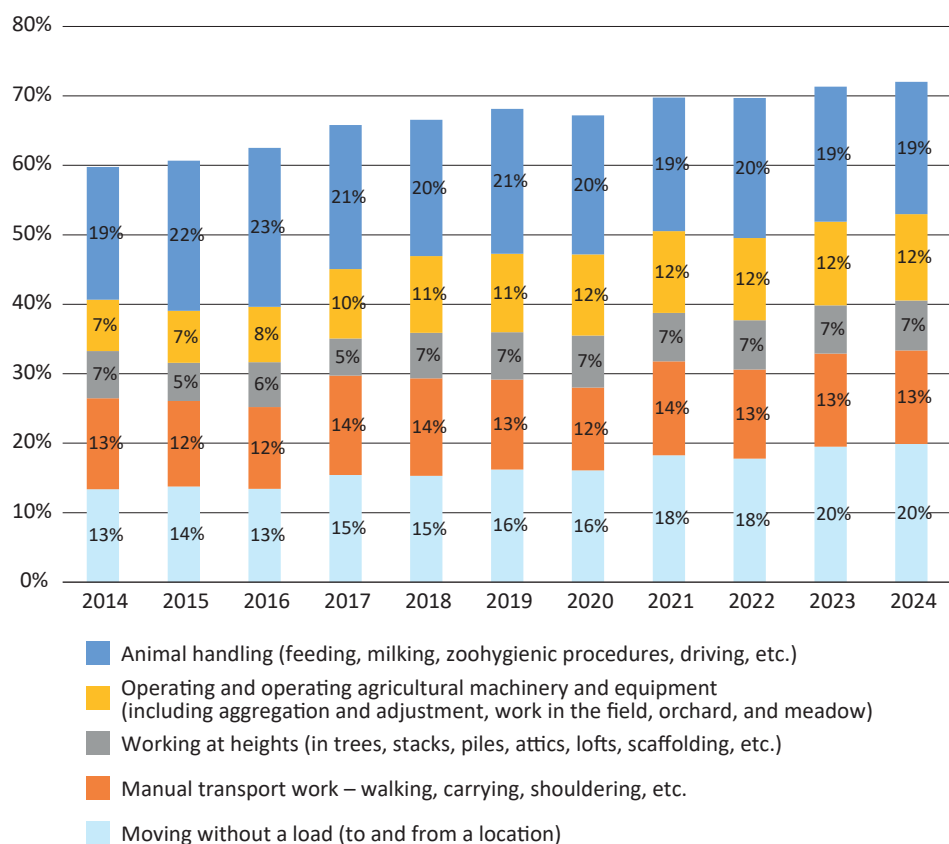


Figure 1. Classification of most frequent agricultural accidents according to work performed in Poland in the years 2014–2024

Rysunek 1. Struktura najczęstszych wypadków rolniczych według rodzaju wykonywanej pracy w Polsce w latach 2014–2024

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

The classification of agricultural accidents with regard to types of machines and equipment used by farmers (and/or employees) in the study period suggest four types:

- agricultural tractors (average 22% of events);
- machines and equipment for wood harvesting and processing (average 20% of events);
- transportation means – trailers, horse-drawn wagons, delivery vehicles, etc. (average 15% of events);
- remaining machines, equipment and tools (average 15% of events).

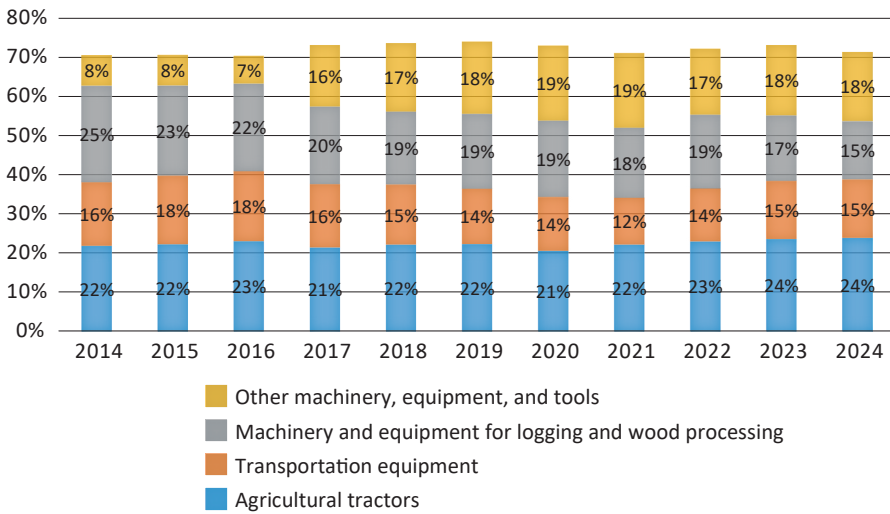


Figure 2. Classification structure for agricultural accidents in Poland according to types of machines and equipment used in the years 2014–2024

Rysunek 2. Struktura klasyfikacji wypadków przy pracy w rolnictwie w Polsce według rodzajów użytkowanych maszyn i urządzeń w latach 2014–2024

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

Figure 2 presents the changes in classification structures regarding agricultural accidents in Poland for 2014 to 2024 showing a reduction in events pertaining to servicing machines and equipment for wood harvesting and processing (from 25% in 2014, to 15% in 2024). The number of accidents associated with servicing agricultural tractors remains stable yet high (24% in 2024), and transportation means – 15% for 2024. However, the rate of accidents in the category of ‘other machines, equipment and tools’ has risen by 10% for the study period. This category

includes electric hand tools (their share in the accidents classification structure for the study period remains steady averaging around 6%) and other machines, equipment and tools. Troubling is the fact that this group has the highest medium-term rate rise for the study period – of around 26%. During the operation of this group of machines and equipment, the number of agricultural accidents increased from 1% in 2014 to 9% in 2024.

The analysis of agricultural accident classification structure pertaining to the category of causes of accidents for the study period indicates a conclusion that human and technical factors failed most frequently (see Table 2). The incidence of the human factor in agricultural accidents is the highest and rising – from 43% in 2014, to 57% in 2024. Comparing the incidence of agricultural accidents resulting from human factors between 2024 and 2014 rose by 33%, rising by a yearly average of 3%. A deeper analysis of human-caused agricultural accidents for the study period reveals the following breakdown by percentage:

- improper farmer or employee behaviour – on average 33% of events (e.g. improper movement of limbs in danger zones, climbing up or down ladders, platforms, etc.);
- improper operation of machines, equipment and tools – on average 22% of events (e.g. improper grasping or holding tools, work materials and articles; climbing in to or down from trailers or wagons; servicing and using agricultural machines and equipment, such as regulation, repair, aggregation);
- not utilising work protection and safety equipment – on average 21% of events (e.g. not using individual protection measures, lack of safety shoes);
- inappropriate farmer or employee behaviour – on average 13% of events – caused by, for example haste;
- improper psychophysical condition of farmer or employee endangering operational safety – on average 11%).

Table 2. Agricultural accident-cause structure in Poland in the years 2014–2024

Tabela 2. Struktura przyczyn wypadków rolniczych w Polsce w latach 2014–2024

Years	Cause categories			
	Human	Organisational	Technical	Others
2014	43%	10%	22%	25%
2015	43%	9%	19%	29%
2016	46%	9%	20%	25%
2017	53%	10%	30%	7%

Table 2. – cont.**Tabela 2.** – cd.

Years	Cause categories			
	Human	Organisational	Technical	Others
2018	56%	10%	27%	7%
2019	56%	10%	25%	9%
2020	58%	11%	24%	7%
2021	56%	9%	27%	8%
2022	57%	10%	26%	7%
2023	56%	11%	26%	7%
2024	57%	10%	26%	7%
Single-base indexing (2014 = 100)	133%	100%	121%	27%
Medium-term rate of change	103%	100%	102%	88%

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

In the period studied, the incidence of agricultural accidents in Poland due to technical causes also rose. The number of events noted in this category rose by 21%, with a medium-term rate of change of 2%. Deeper analysis of the classification structure of agricultural accidents in Poland caused by technical factors revealed the primary causes:

- improper yard condition, circulation routes, manoeuvring areas, etc. in the farms (ca. 60% of events) including poor pavement surfaces (uneven, slick, muddy);
- improper condition of buildings and structures (ca. 16% of events) including faulty building construction, stairs, and animal stalls, unsecured drop zones and manure channels, high door thresholds, uneven floor levels, etc.;
- improper condition of machines, equipment and tools (ca. 12% of events) including missing or inadequate shields and safeguards of moving machine and equipment parts;
- improper condition of ladders, platforms, scaffolding, and other helpful elements on farms (ca. 8% of events).

In turn, the incidence of Poland's agricultural accidents caused by organisational factors is stable for the study's period coming in at around 10%, including events associated with work organisation on farms.

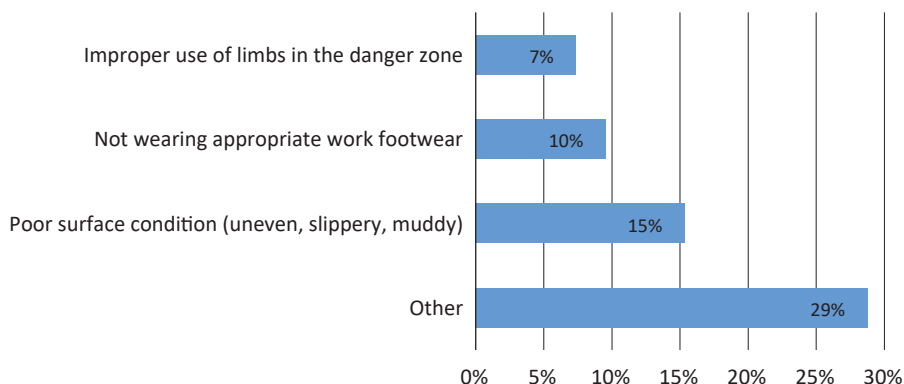


Figure 3. Classification structure of Poland's agricultural accidents according to causes in 2024

Rysunek 3. Struktura wypadków rolniczych w Polsce według głównych przyczyn wypadków w 2024 r.

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

Figure 3 presents four main causes of agricultural accidents in Poland for 2024 and it appears that the 'Other' category is the largest i.e. 29% of all events. The assessment of agricultural accident causes may indicate the need to expand the examination of the 'Other' category. Among the defined category's accident causes, the largest group are events caused by bad pavement condition (uneven, slick, muddy). It is worth noting that the incidence of agricultural accident events caused by the above has been systematically falling, from 24% in 2014, to 15% in 2024. Also noteworthy is the drop of events caused by inappropriate limb movements in danger zones – from 9% in 2014, to 7% in 2024.

For the years of the study period, the number of agricultural accident events that have risen have been caused by:

- inappropriate footwear (a rise from 0% in 2014, to 10% in 2024);
- improper methods of animal care, including extra care when working with dangerous animals (an increase from 2% in 2014, to 5% in 2024);
- not taking advantage of, or improper climbing up or down ladders, platforms or scaffolding when working at height (a rise from 0% in 2014, to 3% in 2024);
- lack of appropriate work clothing and footwear (a rise from 0% in 2014, to 2% in 2024);
- lack of appropriate work resources, such as machines, equipment, ladders, platforms, carts, etc. (a rise from 0% in 2014, to 2% in 2024).

The classification structure analysis of agricultural accidents in Poland according to the time of day concludes that during the period close to half of the events took place in the afternoon, and over a third occurred in the morning hours. From 2014 to 2024, accidents occurring in the evening hours fell by 3% (see Figure 4).

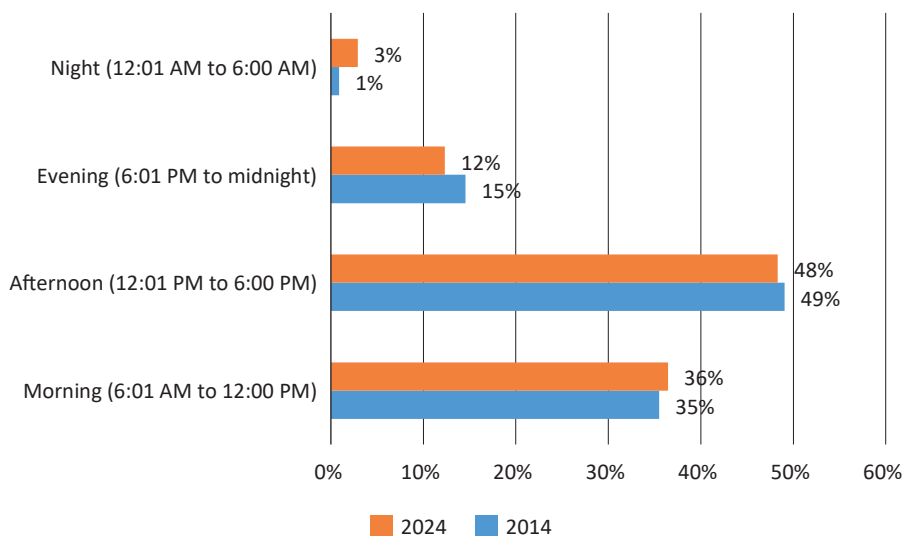


Figure 4. Classification structure of Poland's agricultural accidents according to time of day in the years 2014–2024

Rysunek 4. Struktura wypadków rolniczych według pory dnia w Polsce w latach 2014–2024

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

The classification structure analysis of agricultural accidents in Poland according to the day of the week in 2024 is stable. Figure 5 presents the distribution for 2024 and shows fewest events on Sundays (ca. 8%), and the most on Saturdays (ca. 17%). The distribution for the remaining days of the week are very similar.

According to Zielińska (2026b) the most frequently paid accident benefit is lump-sum compensation. This is payable, inter alia, to the insured person (a farmer or household member) in the event of permanent or long-term physical injury resulting from an occupational accident in agriculture, and in the event of death – to eligible family members. The amount of the benefit is proportional: it is determined as the product of (1) the rate per 1% of injury and (2) the percentage of injury assessed by the competent adjudicating authority. The amount of compensation

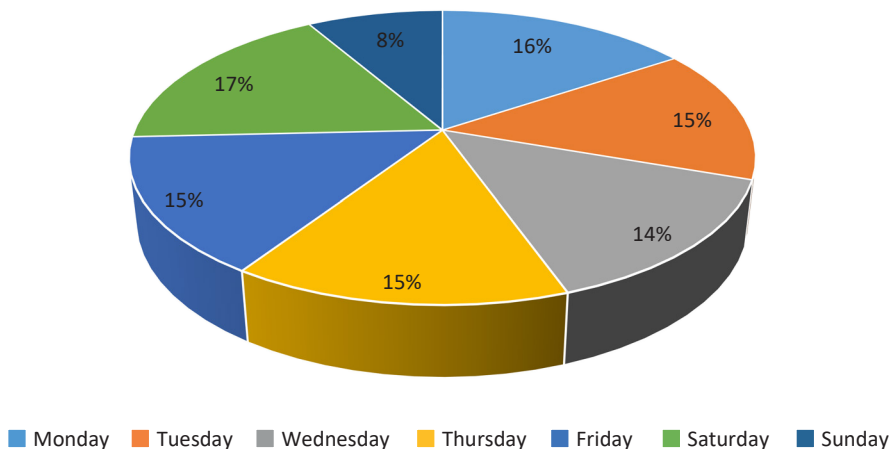


Figure 5. Classification structure of Poland's agricultural accidents according to day of the week for 2024

Rysunek 5. Struktura wypadków rolniczych w Polsce według dni tygodnia w 2024 r.

Source: own study based on ASIF data.

Źródło: opracowanie własne na podstawie danych KRUS.

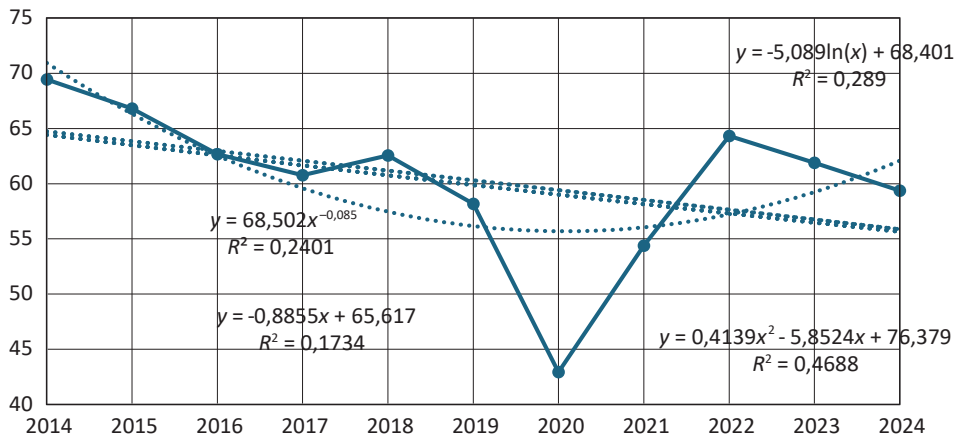


Figure 6. Amount of benefit payments to farmers in Poland in the years 2014–2024 in respect of accidents and occupational diseases (in PLN million)

Rysunek 6. Kwota wypłat ze świadczeń dla rolników w Polsce w latach 2014–2024 z tytułu wypadków i chorób zawodowych (w mln zł)

Source: Zielińska (2026a).

Źródło: Zielińska (2026a).

to farmers in Poland has been steadily declining (see Figure 6), from nearly PLN 69 million in 2014 to PLN 59 million in 2024, representing a decrease in benefit payments of more than PLN 10 million, i.e. 15%.¹

6. Conclusion

Within the framework of this article, Poland's agricultural accidents have been presented through an array of economic theories such as human capital, risk economics and institutional economics. A loss of health by a farmer directly lowers a farm's effectiveness; subjective disregard of dangers leads to less than optimal production decisions. Essential roles in the process of improving work safety are played by national institutions, regulations and educational activism. The review of literature presented on the issue systematises research on agricultural accidents in the framework of numerous contexts – from medical and economic to modern analyses utilising artificial intelligence. This article's analyses of research materials is associated with economic and statistical contexts regarding studying agricultural accidents. The empirical analysis led to the following conclusions:

1. The analysis of the research data indicates the increasing importance of the human factor in the structure of occupational accidents in Polish agriculture, which is closely related to human capital theory. According to this theory, knowledge, experience, health status, professional qualifications, and the ability to organise work safely constitute forms of human capital that significantly influence the efficiency of farm management and the level of occupational safety. From 2014 to 2024, the involvement of this factor is noted as its impact is clearly rising; in 2024 it reached a level of 57% significance. This phenomenon accompanied the rise in accidents which may remain in connection with various conditions coinciding with farm work, such as farm-work intensity, fatigue or time limits. The tendencies observed indicate validation to earmark more organisational and behavioural attention aspects of farm work. Information and educational activity directed to raising awareness of danger resulting from every day work habits may be one of the possible supplements to current preventive measures. In this context, taking into account the human factor in the initiatives supporting work safety on farms may cause better identification and reducing accident risk.
2. The findings are also consistent with the assumptions of the economics of risk and uncertainty. The data from the period 2014 to 2024 indicate gradual

¹ More information on the number of people insured, the costs of benefits for accidents at work in agriculture and forecasts for 2026–2027 can be found in the article (Zielińska, 2026a).

growth in the significance associated with the operation of selected machine and equipment used in agricultural activity, with special attention directed to electric hand tools and other auxiliary machines. Even though their share in the general accident incidence remains relatively low, the noted rise – from 1% (2014) to 9% in 2024 – may reflect increased use of this type of equipment in every day farm work and better adaptation of safe usage thereof in changing work conditions. The increasing proportion of accidents associated with the use of electric hand tools and auxiliary machinery may be interpreted as a consequence of farmers' decision-making under conditions of economic pressure, seasonal production cycles, and limited labour resources. Efforts to improve productivity or reduce the time required to perform agricultural tasks may lead farmers to accept a higher level of occupational risk, thereby increasing the likelihood of occupational accidents.

3. Market failure theory also provides an important perspective for interpreting the findings. The persistence of a high number of occupational accidents despite ongoing technological progress suggests that market mechanisms alone are insufficient to ensure an optimal level of occupational safety in agriculture. This may be attributed to information asymmetry, limited awareness of occupational risks, and the underinvestment in preventive measures. In the authors' opinion therefore information and educational activities promoting the safe use of power tools and auxiliary machinery should be expanded, taking into account their specific characteristics and their increasing use on farms.
4. On the basis of data pertaining to agricultural accidents and days of the week, it is obvious that the lowest accident events occur on Sunday, as opposed to the highest incidence on Saturday. The remaining days show similar levels which may indicate that risk levels are distributed evenly during the working week and connected to the everyday character of farm work. It is recommended to pay particular attention to work organisation at weekends, especially Saturday, when there seems to be a higher incidence of events. Promoting balanced behaviour between work and rest may encourage limiting accident risk, especially towards the end of the week. At the same time, the empirical analysis indicates that technological development does not automatically lead to improvements in occupational safety. The increasing use of modern machinery and equipment gives rise to new hazards when it is not accompanied by an adequate level of user knowledge, appropriate work organisation, and effective training and supervision systems. These findings confirm the complementary nature of the economic theories examined, which collectively provide a comprehensive framework for explaining the relationships among the behaviour

of participants in the agricultural production process, economic conditions, institutional arrangements, and the level of occupational safety in agriculture. The results of the study therefore indicate that occupational accidents in agriculture cannot be attributed solely to technical factors. Rather, they are the outcome of the interaction of economic, organisational, institutional, and behavioural factors. This finding supports the application of human capital theory, the economics of risk and uncertainty, market failure theory, and institutional economics as an integrated theoretical framework for interpreting the empirical evidence presented in this study.

5. The classification structure analysis of agricultural accidents in Poland according to the time of day for the study period indicates that the highest risk of accidents occurs after noon, which accounts for close to half of accident events. This may bear witness to growing danger due to fatigue and extended work time for farmers and/or employees. The authors' suggest that it is advisable to intensify preventive and educational efforts and direct them at safe work organisation in afternoon and evening hours with specific focus on risk resulting from fatigue.

The analysis of empirical material conducted indicates the merit of applying data in a long-term period as the basis for planning long-term educational and information efforts applying them to everyday work rhythms on farms. The contribution of this study to the existing body of knowledge is both theoretical and practical. From a theoretical perspective, the study advances the economic approach to occupational safety in agriculture by demonstrating the complementary explanatory value of different economic theories in understanding the causes and mechanisms of occupational accidents. From an empirical perspective, it provides up-to-date evidence on changes in the structure of occupational accidents in Poland over the period 2014–2024 and identifies the key risk factors associated with work organisation, the use of agricultural machinery, and human behaviour. From a practical perspective, the findings may serve as a basis for improving preventive measures implemented by institutions responsible for occupational safety in agriculture, designing more effective training programmes, and supporting the development of public policies aimed at reducing the incidence of occupational accidents in the agricultural sector.

The literature review, along with the authors' research confirms that effective accident prevention requires a systematic approach which joins education, modern techniques and appropriate financial support.

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Determinanty wypadków przy pracy w polskim rolnictwie w ujęciu nurtu ekonomicznego

Abstrakt

Cel pracy: Wypadki przy pracy stanowią ważny problem ekonomiczno-społeczny. W artykule dokonano przeglądu literatury wraz z analizą materiału badawczego. Celem pracy była analiza wypadków w rolnictwie w kontekście wybranych teorii ekonomicznych oraz kluczowych czynników determinujących ich występowanie.

Metoda badawcza: Kwerendę literatury przeprowadzono w formie przeglądu narracyjnego wspieranego analizą bibliometryczną. Analizie poddano publikacje indeksowane w bazach Web of Science i Scopus, uzupełnione o wyszukiwanie w Google Scholar, w celu identyfikacji dominujących kierunków badawczych oraz podejść metodologicznych dotyczących wypadków przy pracy w rolnictwie. W części empirycznej badania przeanalizowano dane wtórne pozyskane z Kasy Rolniczego Ubezpieczenia Społecznego (KRUS), obejmujące strukturę wypadków przy pracy w rolnictwie w Polsce w latach 2014–2024. Wyniki badań opracowano za pomocą analizy trendów czasowych, dzięki czemu można lepiej zrozumieć kierunek zmian przyczyn wypadków przy pracy w rolnictwie.

Kluczowe wyniki: Z przeprowadzonych badań wynika, że liczba wypadków rolniczych w zakresie obsługi i eksploatacji maszyn oraz urządzeń rolniczych wzrasta. Liczba wypadków w obszarze obsługi zwierząt utrzymuje się na stałym i wysokim poziomie.

Główne wnioski: Niepokojący jest fakt, że liczba wypadków w rolnictwie z udziałem czynnika ludzkiego jest najwyższa i stale rośnie. W 2024 r. w porównaniu z 2014 r. liczba wypadków w rolnictwie z udziałem czynnika ludzkiego wzrosła aż o 33%. Wypadki te były powodowane m.in.: niewłaściwym postępowaniem rolnika. Analizy prowadzone w długich szeregach czasowych mogą przyczynić się do lepszego poznania uwarunkowań wypadkowości w rolnictwie i stanowić wartościowe uzupełnienie dotychczasowych badań.

Słowa kluczowe: ekonomia ryzyka, wypadki, rolnictwo, kapitał ludzki.