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Farm fatalities in Northern Ireland agriculture: What fifty years of data tell us

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A B S T R A C T

Agriculture is one of the most hazardous sectors in terms of fatal and non-fatal accidents. This paper utilises an administrative dataset that recorded farm fatalities in Northern Ireland over a 50 year timeframe (1968–2017) to undertake an age-period analysis of accident related mortality rates by sex, cause of death, season, and day of the week. Public policies aimed to improve farm safety should consider that fatalities due to animals have increased while the incidence of deaths due to vehicles and equipment has substantially decreased over the years although it is still the primary cause of death. With respect to age, elderly still actively involved in farming and children in the spring and at week-ends are most exposed to the risk of a fatal accident. Overall, men die on farms five times more than women.

1. Introduction

The agricultural sector makes up half of the world's labour force and it is one of the most hazardous occupational sectors to work in contributing to some 170,000 fatalities annually (International Labour Organization, 2020). The high incidence of fatal accidents in agriculture is linked to a range of hazards present on a farm and also that farming is characterised by long working hours, relying solely on family labour and often working alone (Lehtola et al., 2008). The most common causes of farm fatalities are tractors, machinery, falls, animals, toxic gases, and electrocution. Furthermore, for the majority of farm family businesses the place of residence, the farmhouse, is situated within the boundaries of the farmland making children and elderly family members the most exposed to the risk of suffering an accident resulting in a fatal injury (Arana et al., 2010; Nilsson, 2016).

Around the world, public authorities are aware of the dangers associated with working and living on a farm and continue to allocate significant levels of resources to improve farm safety. For example, the United Kingdom (UK) has adopted several policies aimed at improving farm safety such as risk assessments, guidance on construction and maintenance, and setting in place compulsory measures around handling hazardous materials, livestock, and machinery (Health and Safety Executive, HSE, 2021). Similarly, the EU Directive 89/39/EEC for workers in employment (self-employed excluded) requires mandatory risk assessments in the workplace and guarantees minimum requirements for health and safety in all the member states. Despite this, high fatal rates persist in agriculture to indicate that these policies did not succeed (Caffaro et al., 2018).

This paper aims to analyse fifty years of farm fatalities in a specific region of the UK, namely Northern Ireland (NI). Compared to the agricultural sector in the rest of the UK, NI agriculture makes a higher contribution to GDP and employs more of the labour force (Department of Agricultural and Rural Affairs, DAERA, 2021a). The majority of the 25,000 farms are small family operated businesses specialising in livestock production namely beef, sheep, and dairy. Specifically, we have focused on all fatalities within the agricultural sector from 1968 to 2017 in Northern Ireland to estimate the fatality rate via an age-period count data model by sex, cause of accident, seasonality, and day of the week. Although there is a substantial body of research on farm fatalities, to our knowledge this is the first study that covers fifty years and that analyses the evolution of farm fatality rate over time for different characteristics of the accident and the injured person (Lee et al., 2017; Shah et al., 2011; Arana et al., 2010).

The results indicate that fatality rates due to animals are still increasing. Conversely, fatality rates due to vehicles and equipment showed the most marked decrease over time and especially in the spring

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Table 1
Farm Fatalities by Cause of Death in Selected Countries (percentage multiplied by 100).

	Period	Vehicles & Equipment	Animal	Falls from Height	Struck by an Object	Other
Australia[A]	2003–2011	49.8	5.9	6.9	24.9	12.5
Canada[B]	1990–2008	63.8	6.2	5.1	8.3	16.5
Great Britain[C]	2018–2019	43.6	23.1	17.9	7.7	7.7
Northern Ireland[D]	2009–2018	32.4	26.5	27.9	–	13.2
Republic of Ireland[E]	2005–2014	48.7	13.0	17.9	7.0	13.4
United States[F]	2018–2019	76.8	8.7	6.1	–	8.4

A: Safe Work Australia (2013); B: Canadian Injury Report (2013); C: HSE (2021); D: HSENI (2020b); E: Lee et al. (2017); F: Bureau of Labor Statistics (2021).

and summer seasons. Fatality rates exhibited a U-shaped distribution in relation to age with the oldest being the most exposed to farm accidents. The highest incidence of fatalities for older individuals happens on those days of the week when farming activities are most intense. In contrast, fatalities involving very young individuals are more likely to occur on Sunday when farming activities could be less intense. Overall, the fatality rate of men was five times higher than for women. The paper is organised as follows: section two reviews the relevant background, the third section describes the data and the estimated models, section four discusses the results, and the final section presents the conclusions.

2. Background

2.1. Fatalities in agriculture

Due to different climate and soil conditions and a heterogeneous production structure, work practices in agriculture are globally differentiated. Despite these variations, similar patterns emerge across countries and over time in relation to causes of accidents and the individuals involved. With regard to the type of accident, vehicles are one of the major causes of accidents (McCurdy and Kwan, 2012; Alavanja et al., 2001). Within this category, tractors, harvesters, and all-terrain vehicles such as sit-astride quads and side-by-side vehicles are major contributors to accidents. These vehicles are designed to cope with a wide variety of terrain types and weather conditions, including steep slopes and muddy roads. Nevertheless, they can be dangerous if used outside their safe operating parameters. The most common fatalities involving vehicles consist of being thrown off a tractor in the situation where it overturns or after loss of control, a collision, or when a pedestrian gets struck or run over by a vehicle. Linked to vehicles are also those fatalities occurring around power take off (PTO) and the PTO drive shafts of a machine if they are used incorrectly or unguarded (McNamara et al., 2019).

Another important cause of fatalities is when an individual is crushed, kicked, butted and/or gored by livestock. These accidents happen in response to unexpected behaviour of the animal when an individual is in close contact and the animal could be under stress for example during milking, veterinary testing, and hoof trimming (Lindahl et al., 2016). Moreover young bulls and livestock not being used to being moved can respond unexpectedly once they are confined in a restricted area (Douphrate et al., 2013).

Many accidents also involve falls from height when agricultural edifices or other farm structures are being built or maintained, for example when replacing and repairing roofs or cleaning valley gutters. Within this category, another common cause is falling from a bale stack or from a vehicles used to transport them. This type of accidents happens generally when no precautions are taken, or the equipment that is used such as ladders, scaffolds, and temporary platforms are defective or used incorrectly (HSE, 2021).

Besides, exposure to toxic substances such as slurry and electrocution have been shown to be among the other residual causes of fatalities on farm. With respect to toxic substances, incidents involve not just farmers, but also people being overcome by toxic gases, drowning as a result of a fall into slurry or liquid stores, or being injured from the collapse of structures containing slurry (Alavanja et al., 2001). Typically, the main reasons are poor maintenance of the storing structures and poor fencing to restrain access to unauthorised individuals. With regard to electricity, fatalities are due to touching anything in contact with overhead power lines (OHPLs) that carry high voltage power. Although the minimum high of OHPLs may be adequate for most work activities, with increased mechanisation within the industry the availability of machinery of greater size and scale, such as telescopic handlers, combine harvesters, and excavators has made operators more susceptible to inadvertently coming into contact with overhead power lines, (HSE, 2021).

In terms of international comparison, Table 1 shows the distribution of farm fatalities by cause of accident in selected developed countries and it indicates vehicles and equipment, animals, falls from height, and being struck by an object are the primary causes of death. With respect to Northern Ireland, Table 1 shows that the region has a relatively low incidence of vehicles and machinery and the highest incidence of fatalities due animals and falls from height.

With regard to the characteristics of the injured person, age plays a major role with more fatal and non-fatal injuries observed for those individuals at the two extremes of the age spectrum, i. e. young and old subjects (Westaby and Lee, 2003). Young farmers with limited farming experience and who do not engage in farm safety training and adopt best practice are more prone to take risks which result in accidents and fatalities. In contrast, older farmers can experience physical and mental decline as a consequence of aging such as visual and auditory weakening and a reduction of reaction times (Browning et al., 1998). Furthermore, a lifetime of undertaking risks in farming practices that have resulted in few accidents and near misses may set a pattern in which older farmers continue to engage in dangerous work practices which result eventually in a serious accident (McLaughlin and Sprufera, 2011). Moreover, despite the fact that agriculture has one of the highest fatality rates across industries, it is the only sector where children may be present on the work premises. Farms are workplaces as well as homes and children, as historical data indicate, are often killed or injured on farms, either because they are working or playing on the farm.

Gender is also a relevant factor in terms of farm fatalities. Form a historical prospective, the agricultural labour force tends to be predominately male. For example, the percentage of the male workforce on Northern Irish farms ranged from 66% to 81% in 1912–2019 (DAERA, 2021b). Nevertheless, with the introduction of more mechanised equipment task specialization by gender has decreased over time and women are now more involved in routine farming activities which may have previously been considered as a ‘man’s job’. McCurdy and Kwan

Table 2
Age Distribution of Northern Irish Farmers in 1993–2016 (percentage multiplied by 100).

Age Class	1993	1995	1997	2000	2003	2005	2007	2010	2013	2016
34 and below	10	8	7	9	7	7	6	5	4	6
35–64	64	65	66	67	68	67	67	68	64	61
65 +	27	26	27	24	25	26	27	27	33	33

Source: EU Structure Survey of Northern Ireland 2016 – 2013 (DAERA, 2021a).

(2012) studied gender differences in young farmers in California and indicated that although girls are less prone to engage in hazardous tasks, they also were less likely to use appropriate safety measures. Moreover, Shortall et al. (2019) analysed Scottish farms and reported that women often engage in farming activities that can put them at risk of injury to show and prove that they are 'authentic' farmers.

Time pressures and workload balance are other factors contributing to farm accidents and fatalities. At a general level, the relationship between workload and the time available to undertake tasks contributes to the level of physical and mental stress of a worker and this can lead to increased accident occurrence. This has two interesting consequences. Firstly, in many Western countries there has been a trend since the mid-nineties for average farm size to increase while the number of active farmers has fallen (Kallioniemi et al., 2009). In addition, global markets have amplified competition and volatility in the returns to agricultural production. All this suggests that when agriculture is subject to structural changes, increased workloads for farmers can result in a higher risk of being involved in an accident. Secondly, this has implications for the day-by-day farming practices as the more intense the level of farming activities becomes the greater is the likelihood of accidents occurring. For example, Goldcamp et al. (2004) reported that the number of fatalities for young US farmers in 1995–2000 is depicted by a bell shaped curve with the peak occurring in the middle of the year, i. e. June and July. Similarly, Lee et al. (2017) reported that the highest number of non-fatal injuries for Irish farmers in 2004–2015 is observed from June to August.

Moreover, farming intensity, particularly at busy periods, may draw in other less experienced family labour and this has been shown to have detrimental consequences particularly for accidents involving young adults and children. As reported by the Centers for Diseases Control and Prevention (CDC, 1999) approximately a half of all injuries sustained by children on a farm occurred when they were being supervised by an adult who was actively conducting farm work at the same time. In other words, if parents want to socialise younger children into farming they have difficulties in undertaking farm work and simultaneously providing the level of supervision that children need in the high hazard environment of a farm.

This overview has a general implication for agricultural fatalities. When farming is still largely a family business, as in NI, most accidents happen to family members as a result of normalisation of hazards considered part of the job from an early age (Shortall et al., 2019). Previous studies indicated that this normalisation process results in more near misses and minor injuries and that these minor and narrowly avoided accidents are significant predictors of a more serious accident occurring, i. e. fatal and non-fatal accidents have the highest likelihood to occur in farms that have already experienced them (Angioloni et al., 2022). Normalisation of danger is a common practice in the most hazardous work environments such as mining, construction, and transportation. Nevertheless, what makes agriculture one of the most dangerous industries is the family nature of the business where less formal regulations and stronger social relationships can exacerbate the feed-back between social norms and risky behaviours (Nordlöf et al., 2015).

2.2. Evolution of Northern Irish agriculture

In the last fifty years, Northern Ireland has witnessed a series of structural changes that have shaped its agricultural sector and affected farm related fatalities. This section provides a brief overview of the main changes.

Firstly, population aging and increased level of education have moved many young individuals out of agriculture and amplified the presence of older farmers. Table 2 shows the incidence of farmers below 34 years decreased from 10% to 6% between 1993 and 2016 while the presence of farmers 65 and older increased from 27% to 33% (DAERA, 2021a).

Secondly, increased level of mechanisation has reduced the labour-intensive work, improved the safety standards of vehicles and equipment and promoted task specialisation. For example, the real value of gross capital investment in agriculture, that includes plant, machinery and vehicles, increased by 54% from 1981 to 2018 (DAERA, 2021c). Similarly, the share of farms that use professional contractors for activities such as harvesting, milking, and spreading manure increased by 20% in 2000–2016 (DAERA, 2021a).

Third, the enterprise profile of production in NI agriculture has evolved with less crops and cereal produced over time and a trend towards more intensive livestock production. Setting aside short term corrections, the livestock sector has increased in terms of both output and livestock numbers. For example, between 1968 and 2018 the number of dairy and beef cows increased by 56% and 36% (DAERA, 2021d). Most of these changes started to be significant after the creation of the EU Single Market in 1993 which opened the market to new consumers for NI producers. As a result of the adoption of common market rules, farmers specialised in areas of production where they had a comparative advance. In NI, production of cattle and dairy increased by 22% in 1990–99 while the number of beef cows reached the highest level ever in 1998 and in 1999 for the dairy cows (DAERA, 2021d). In contrast, in 990 s cereals production decreased by 20% while the acreage of land used in this sector was reduced by 10%.[1]

Fourth, more competitiveness and heavy capital investment has reduced the market share for small scale farmers. Although supermarkets have been present in Northern Ireland since 1960s, their market share started to increase at the end of eighties after the main UK food retailers such as Sainsbury's and Tesco moved into the region for the first time (Alexander and Drake, 2002). Overall, this concentrated agricultural production amongst the large size farms usually characterized by a higher level of health and safety spending than small family businesses (Thomason and Pozzebon, 2002).

In terms of overall magnitude, the farm fatality rate calculated with the methodology described in the next section corresponds to 1.34 per 10,000 in 1968–2017. For comparison purposes, over the period 2005–2017 the fatality rate was 1.16 in NI and 1.14 for Great Britain (GB) (HSE, 2021). These figures are on the same scale as in other

[1] Two other facts are worth to mention about beef and dairy sectors in the 1990s. First, on 16th September of 1992 the British government was forced to withdraw the pound sterling from the European Exchange Rate Mechanism, so-called Black Wednesday. After that, the British currency weakened and this caused a mini boom in agriculture prices for milk, cull cows, calves, and beef steers that achieved an unprecedented maximum in 1994–96 (Alexander and Drake, 2002). Second, the bovine spongiform encephalitis (BSE), also known as mad cow disease, reached a peak in March 1996 when Northern Ireland banned feeding meat and bone meal, decided to slaughter cattle over thirty months of age and put a substantial amount of animals under massive testing.

Table 3
Descriptive Statistics of Farm Fatalities in Northern Ireland 1968–2017.

Type of Variable	Variable	Average	Standard Deviation
Individual Characteristics	Age	42.49	25.52
	Sex (1 if female)	0.07	0.26
Cause of Accident	Vehicles & Equipment	0.53	0.50
	Fall	0.19	0.40
	Animals	0.12	0.32
	Slurry	0.06	0.25
	Electricity	0.05	0.21
	Other	0.05	0.22
Year of Accident	1968–1972	0.16	0.37
	1973–1977	0.15	0.36
	1978–1982	0.13	0.34
	1983–1987	0.11	0.31
	1988–1992	0.07	0.26
	1993–1997	0.11	0.32
	1998–2002	0.06	0.24
	2003–2007	0.07	0.26
	2008–2012	0.07	0.26
	2013–2017	0.06	0.24
Month of Accident	January	0.04	0.19
	February	0.06	0.23
	March	0.06	0.25
	April	0.10	0.30
	May	0.10	0.30
	June	0.13	0.34
	July	0.14	0.35
	August	0.10	0.30
	September	0.10	0.30
	October	0.07	0.25
	November	0.06	0.24
	December	0.05	0.22
Week Day of the Accident	Monday	0.06	0.24
	Tuesday	0.14	0.35
	Wednesday	0.14	0.35
	Thursday	0.15	0.35
	Friday	0.17	0.38
	Saturday	0.18	0.38
	Sunday	0.16	0.37
Observations	508		

All the variables are binary indicators apart from age that ranges from 0 to 90 years. Source: HSENI(2020b).

countries and over a quite lengthy period. For example, Canada reported an average fatality rate equal to 1.3 per 10,000 people in 1990–2008 (Canadian Agricultural Injury Reporting, 2013). Similarly, the fatality rate in Australian agriculture ranged from 2 to 1.5 per 10,000 individuals from 2003 to 2011 (Safe Work Australia, 2013). Despite the differences in farming structure and scale across countries, similarities in terms of magnitude and typology of fatality rates are present. Clearly, these similarities need to be contextualised. For example, while the age profile of the victims is consistent across countries other aspects such as seasonality need to consider the specific circumstances, i. e. farming is more intense in the warm season that is June-August in the Northern hemisphere and December-February in the Southern hemisphere.

Across developed countries, public campaigns have been implemented to reduce the risk of accidents in agriculture. In NI, authorities have been actively engaged in initiatives aimed at improving farm safety. These have included ongoing advertising campaigns such as 'Stop and Think Safe' and 'Making it Safer', and the introduction of mandatory online self-assessments, such as the Farm Safety Action Plan, to allow access to government funded schemes (Health and Safety Executive Northern Ireland - HSENI, 2020a). Similar initiatives can be observed in other countries (Canadian Agricultural Safety Association, 2022; Farm Safety Australia, 2022). Moreover, public authorities need to quantify in economic terms the cost of human life to allocate effectively public resources (e. g. HSE, 2022; Transport Research Foundation, 2022). From this point of view, the results of this study can help policy makers to assess more effectively the cost of human life in agriculture. On this basis, limiting the risks of both adult agricultural workers and farm family members being killed in a farming related accidents is an important area to address and has been the focus of research across many countries (Athanasiov et al., 2005; Jadhav et al., 2016). However, there is a gap in the research knowledge around understanding which factors contribute to farm fatalities especially over a long time period. Drawing on a fifty year dataset of farm fatalities, this study contributes the literature by analysing how different factors such as age, time, gender, cause, season, and day of the week have affected fatalities with a view to ascertaining where policy instruments can be best directed in the future in order to reduce deaths within agriculture.

3. Data and estimation

3.1. Data source and description

The dataset covers all the fatalities of the agricultural sector from 1968 to 2017 in Northern Ireland. The data were collected from investigations carried out into fatal accidents by HSENI and its associated institutional stakeholders (HSENI, 2020b) and include age, sex, date, and cause of death. Overall, the dataset has 508 entry records/fatalities that correspond to 10 deaths per annum in the last 50 years.

Table 3 reports the summary statistics and it shows that the average age of a fatally injured person was 42.5 years and 93% of accidents involved men. The three most common causes of accidents are vehicles and equipment (53%), fall from high (19%), and animal (12%). Amongst the residual causes of accidents, slurry (6%) and electricity (5%) have the highest incidence. The dataset also includes the dates when accidents occurred that allowed to calculate the distribution of fatalities by month and day of the week. Table 3 shows that the incidence of fatalities follows a bell-shaped trend with a peak in June (13%) and July (14%) and the lowest number of deaths at the beginning (January 4%) and end (December 5%) of the year. In contrast, accidents are more uniformly distributed across week days with the exception of Sunday that recorded the lowest frequency (6%).

3.2. Data preparation

The first step to calculate fatality rates is to know the farm population by year, age, and sex. DAERA (2021b) provides information on the labour force by sex per annum. However, no information is available about the age distribution by sex and year for agriculture. Thus, we employed two simplifications. First, we calculate the *size* of the farm population to include those individuals that do not work in agriculture, but are still subject to the risk of a fatality because they live on a farm, namely young and old individuals. For this purpose, we calculated the size of the farm population in a given year and sex category *proportionally* to the size of the general population in the same year and sex category.[2]

Second, we employ the age distribution of the general population to calculate the *age distribution* of the farm population within a year and sex

[2] This requires to specify the cut-off ages of individuals in the agricultural labour force. In developed countries, international classifications consider 16–64 years as the cuff-off age of the labour force (OECD, 2021). In Northern Ireland, agriculture is based on small farms run at the household level where the age to be involved in farming can start earlier and stop later. In addition, anecdotal evidence from the farm census officers indicated that the age distribution is skewed towards old groups. Consequently, we employed 13–70 years as cut-off ages to calculate the size of the farm population proportionally to the size of the general population in a given year and sex class. Results based on wider cut-off points such as 10–75 are qualitatively and quantitatively equivalent.

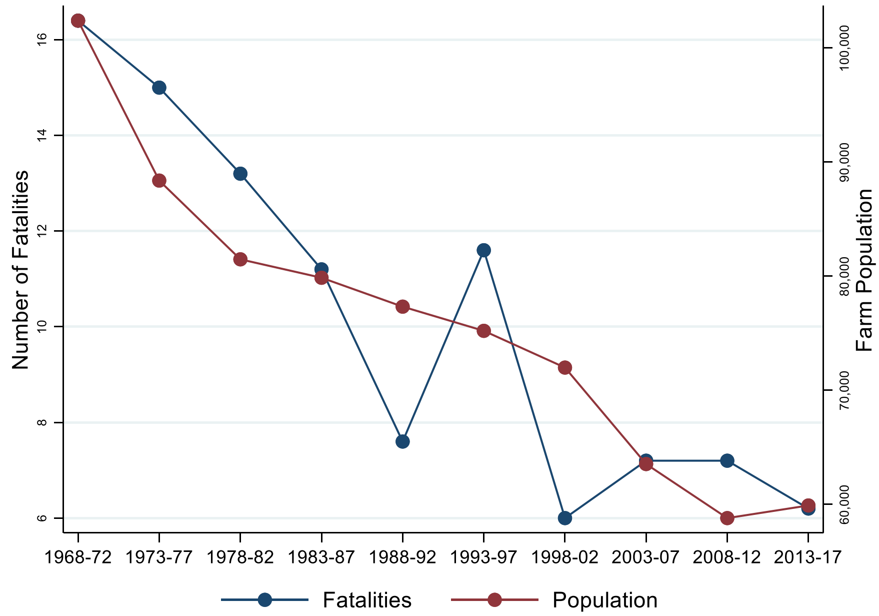

Fig. 1. Farm Fatalities and Farm Population in Northern Ireland in 1968-2017
Sources: DAERA (2021b) and NISRA (2021).

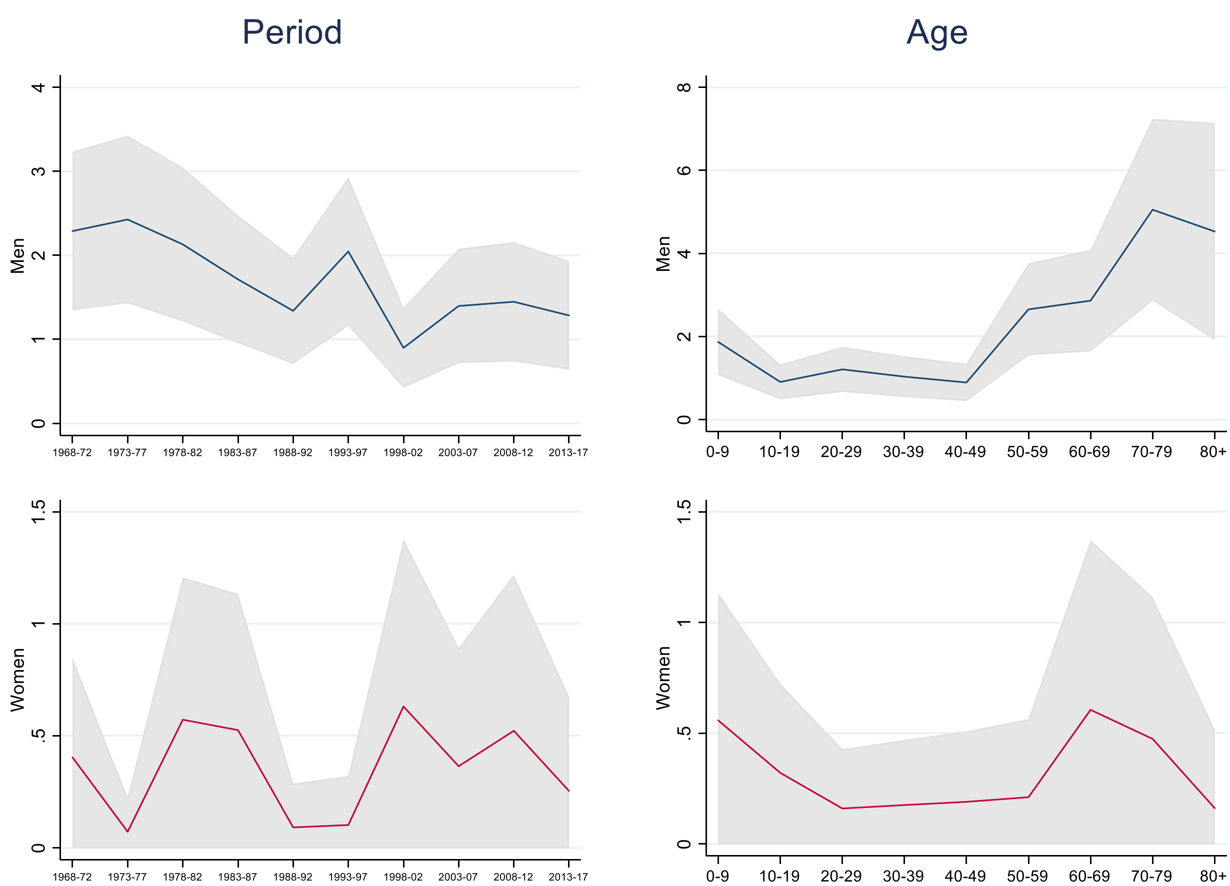

Fig. 2. Farm Fatality Rate by Period, Age, and Sex Continuous line: expected farm fatality rate per 10,000 farm people. Grey area: ± 95% confidence intervals. Charts are plotted on different y-axes as shown in figure.

Table 4
Effect of Period and Age on Farm Fatality Rate by Sex, Cause, and Season.

		Sex		*Cause*				*Season*			
		Men	Women	Tractor	Fall	Animal	Other Cause	Jan-Mar	Apr-Jun	July-Sep	Oct-Dec
Period	1973–1977	0.20	-0.29 *	0.26	-0.17	0.09	-0.10	-0.45	0.30	-0.51	0.88
	1978–1982	-0.19	0.16	0.01	-0.02	0.10	-0.07	-0.13	-0.11	0.14	-0.07
	1983–1987	-0.78	0.12	-0.41 *	-0.01	0.14	-0.02	-0.23	-0.31	-0.28	-0.31
	1988–1992	-1.31 * *	-0.27 *	-0.41 *	-0.24	0.10	-0.19 * *	-0.57	-0.54	-1.76 * **	-0.29
	1993–1997	-0.35	-0.26	-0.30	-0.09	0.20 * *	0.04	-0.29	-0.03	-0.62	0.38
	1998–2002	-1.93 * **	0.23	-0.76 * **	-0.14	0.20 *	-0.21 * *	-0.79 *	-1.96 * **	-0.79	-0.38
	2003–2007	-1.27 * *	-0.01	-0.64 * **	-0.21	0.53 * **	-0.17 *	-0.73	-0.74	-0.96	-0.14
	2007–2012	-1.25 * *	0.14	-0.72 * **	0.04	0.29 *	-0.10	0.24	-0.20	-1.77 * **	-0.39
	2013–2017	-1.53 * **	-0.12	-0.70 * **	-0.17	0.36 * **	-0.19 * *	-0.28	-1.02	-1.82 * **	-0.13
Age	10–19 years	-0.88 * **	-0.25	-0.07	-0.12	0.09	-0.10 * **	-0.12	-1.50 * **	-0.05	-0.24
	20–29 years	-0.57 *	-0.41 * *	-0.17	-0.16 * *	0.10	-0.07	-0.12	-0.95 * *	-0.03	0.03
	30–39 years	-0.71 * *	-0.40 * *	-0.17	-0.09	0.14	-0.02	-0.14	-1.27 * **	-0.17	0.03
	40–49 years	-0.85 * **	-0.39 *	-0.19	-0.08	0.10	-0.19 *	-0.10	-1.44 * **	-0.64	0.18
	50–59 years	0.88 * *	-0.37 *	0.57 * **	0.22	0.20	0.04	0.57	0.38	1.32 * *	0.97 * *
	60–69 years	1.06 * *	0.04	0.40 * *	0.45 * *	0.20 * **	-0.21 * *	1.87 * **	0.87	0.79	0.68 * **
	70–79 years	3.28 * **	-0.10	0.71 * **	0.63 * **	0.53 * **	-0.17 * **	0.44	1.51	3.13 * **	2.59
	80 +	2.94 * *	-0.42 *	0.50	-0.04	0.29 * *	-0.10 * **	0.92	0.55	0.95	0.56
Overall Rate		1.74	0.35	0.71	0.27	0.16	0.22	0.84	1.34	1.80	0.95

Marginal effects calculated as discrete change from the base (period: 1968–1972; age: 0–9 years) of the expected farm fatality rate per 10,000 farm people. Statistical significance calculated from the standard errors estimated with the delta method. * ,* *,* ** denotes statistical significance at the 10%, 5%, 1% and level, respectively.

category (NISRA, 2021). Specifically, the farm population FP_{tas} in year t, age a, and sex s was calculated as:

$$FP_{tas} = \frac{FL_{ts}}{lf_{ts}} \bullet \mathrm{p}_{\mathrm{tas}} \quad (1)$$

Where FL_{ts} is the farm labour force in year t and sex s provided by DAERA (2021b), lf_{ts} is the percentage of working age individuals from the general population, and p_{tas} is the percentage of individuals in the general population in year t, age a, and sex s, both provided by NISRA (2021). The ratio in Eq. (1) calculates the size of the farm population while the multiplication by p_{tas} distributes the size over age classes.

The number of fatalities and the farm population were cross-tabulated into 10 groups by 5 years intervals, i.e. 1968–72, 1973–77, up to 2013–17 as shown in Table 3. Similarly, we grouped the data in 9 classes of age ranges commencing from 0 to 9 years and then10–19 years, and so on up to 70–79 years. The last age category includes all those fatalities that involved those individuals who were aged 80 or more. Fig. 1 shows the decreasing trend of the farm population in Northern Ireland that moved from above 100,000 units in 1968–73 to 60,000 individuals in 2013–17 per annum. Besides, Fig. 1 shows that the number of fatalities decreased steadily from 1968-73 (16) to 2013–17 (6) apart from the peak in the 1993–97.

3.3. Estimation

Health studies employ age-period-cohort (APC) analysis to study morbidity and mortality rates (Colvin and McLaughlin, 2021; Jean et al., 2013; Malvezzi et al., 2010) and more generally to analyse the temporal evolution of demographic rates (Canizares and Badley, 2018). Within this debate, age effects are defined as those affecting individuals with a certain age, period effects include everybody in a given time, and cohort effects are common amongst those born in the same year. Due to the limited size of the agricultural sector and its scattered distribution with respect to the overall population, cohort effects of farm fatalities could have a limited incidence and thus we preliminary tested their presence via the cohortality coefficient (Chauvel et al., 2016). The cohortality coefficient compares the fit of the APC model to the fit of a model without cohort effects, i. e. an age-period (AP) model, and it is equal to 0 if cohorts effects are not present and 1 if they perfectly fit. We did this for the grouped data as described in the previous section and for the ungrouped data. Overall, Table 1A of the appendix shows that the highest value of the cohortality coefficient is 0.18 and most of the times not different from 0. Besides, the Bayes information criteria indicates that the AP models performs better than the APC model in 32 out of 34 comparisons. Consequently, the analysis focus is on AP models. Specifically, we employ a Poisson count data model with farm population as exposure variable and fixed effects for age and period:

$$P(Y = y_{ta}) = \frac{{\lambda_{ta}}^{y_{ta}} \bullet e^{-\lambda_{ta}}}{y_{ta}!} \quad (2)$$

$$\lambda_{ta} = \exp(\boldsymbol{X}'_{ta} \bullet \boldsymbol{\beta} + \ln(\mathrm{FP}_{\mathrm{ta}})) \quad (3)$$

$$\boldsymbol{X}_{ta} = (\boldsymbol{t}, \quad \boldsymbol{a}) \quad (4)$$

Where y_{ta} is the observed number of fatalities in period t and age class a, $\boldsymbol{X}_{ta}$ is a matrix of fixed effects for period and age including the intercept, and FP_{ta} is the farm population in period t and age class a. The employed specification is based on step functions and produces less smooth age and period functions (Sasieni, 2012). Nevertheless, it has two advantages. First, given the focus on the age-period analysis, the model estimates one parameter for every age and period separately and this greatly facilitates the interpretation of the results. Secondly, the model is still flexible since it has as many parameters as in other studies based on more sophisticated APC specifications (Chauvel et al., 2016; Sasieni, 2012).

We estimate the model in Eqs. (2)–(4) by sex, cause of accident, season, and week day and employed the analysis of the statistical differences to study how the fatality rate changes over time and age for each one of these groups. The estimation was performed via maximum likelihood estimation. Fatality rates are defined as number of deaths per

Fig. 3. Farm Fatality Rate by Age-Period for Different Cause of Accident, Continuous line: expected farm fatality rate per 10,000 farm people. Grey area: ± 95% confidence intervals. Charts are plotted on different y-axes as shown in figure.

10,000 farm people.

4. Results

4.1. Gender

With respect to gender, the first aspect is that a time trend of the fatality rate is recognisable only for men. The left top panel of Fig. 2 shows that the fatality rate of men has the highest incidence in 1968–72 period and, after that, it decreases. The analysis in Table 4 indicates that the decreasing trend started to be significant in 1988–92. After that, the only years not statistically different from the base period were 1993–97 when a two digit number of fatalities was recorded for five years in a row. These results are relevant given that 93% of all the fatalities involved men. In contrast, fatality rates of women exhibit a more erratic path with no specific time trend recognizable from Fig. 2 and Table 4.

Second, the analysis of the fatality rates with respect to age indicate a U-shaped function skewed towards older individuals. Specifically, Fig. 2 shows that the male fatality rate has a peak for very young individuals (0–9 years), it decreases between 10 and 49 years, and then it increases after 50 years to reach a maximum at 70–79 years being the fatality rate just below 5 deaths per 10,000 in this age class. Women exhibit a similar path although the peak of fatalities is at 60–69 years probably linked to less involvement in active farming as they get older (Contzen et al., 2017). Women also exhibit a relatively higher incidence of fatalities for the youngest age group (0–9 years) compared to men. This is confirmed by the distribution of age by gender: 43 years for men and 31 years for women. In terms of magnitude, the bottom row of Table 4 indicates that men experienced 5 more fatalities than women being the fatality rate 1.74 and 0.35. For comparison purposes, Dimich-Ward et al. (2004)

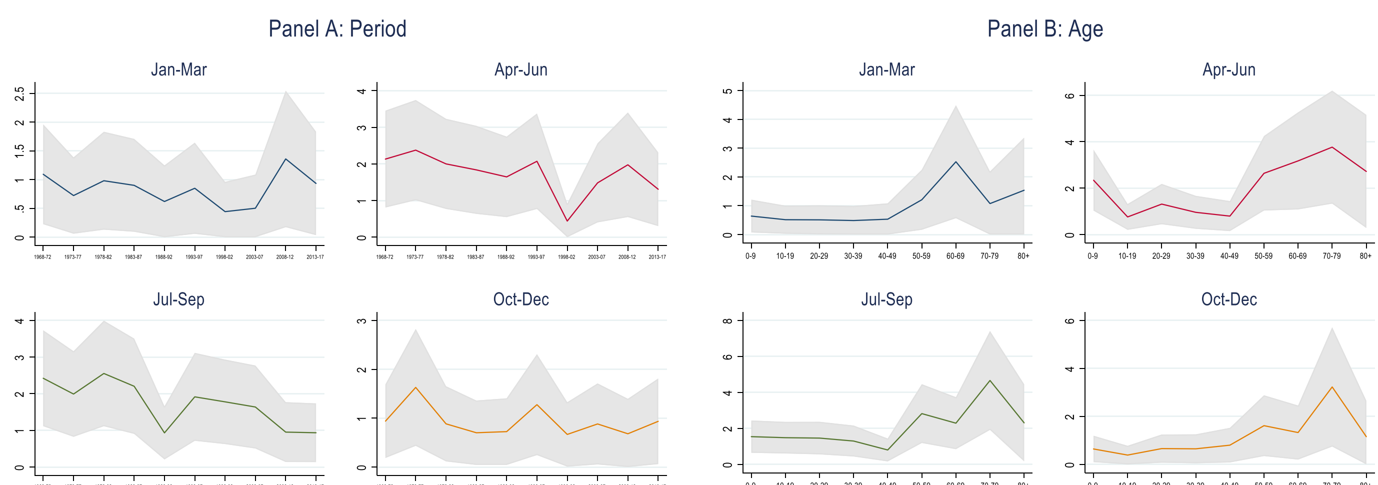

Fig. 4. Farm Fatality Rate by Age-Period in Different Seasons, Continuous line: expected farm fatality rate per 10,000 farm people. Grey area: ± 95% confidence intervals. Charts are plotted on different y-axes as shown in figure.

Table 5
Effect of Period and Age on Farm Fatality Rate by Week Day.

	Variable	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Period	1973–1977	-0.19	0.92	0.16	-0.96	0.53	-1.12	0.61
	1978–1982	-1.32	0.25	-0.44	0.90	0.44	-0.44	0.26
	1983–1987	1.24	0.91	-0.41	-1.21	-2.36 * *	-0.98	1.15
	1988–1992	-0.94	0.32	-0.35	-1.39	-2.55 * **	-1.12	0.06
	1993–1997	-0.06	0.59	-0.29	-0.91	-1.85 *	0.52	0.77
	1998–2002	-1.24	0.88	-1.14	-1.56 *	-3.22 * **	-1.86 * **	1.04 *
	2003–2007	-0.37	1.65 *	-1.02	-1.68 *	-2.41 * *	-1.30	0.38
	2007–2012	-0.38	0.70	-0.96	-0.78	-2.35 * *	-0.96	0.41
	2013–2017	-1.69	0.08	-0.74	-0.89	-1.60	-1.76 * *	0.64
Age	10–19 years	-0.02	-0.48	-0.93 *	-0.31	0.03	-1.14 * *	-0.72 *
	20–29 years	0.53	-0.37	-0.80	-0.19	-0.14	-0.32	-0.82 * *
	30–39 years	-0.31	-0.43	-1.36 * **	0.35	0.28	-0.54	-0.81 * *
	40–49 years	0.11	-0.97	-1.01 *	-0.44	0.25	-1.02 *	-0.63
	50–59 years	1.11	0.51	-0.22	1.87 * *	1.86 * *	0.30	0.31
	60–69 years	0.98	1.52 *	0.67	1.81 * *	2.16 * **	-0.14	-0.30
	70–79 years	4.20	3.17 * *	0.68	3.28 * **	1.46	2.22 *	0.31
	80 +	1.18	0.06	0.97	1.01	2.61	-1.10	0.38
Overall rate		1.35	1.33	1.37	1.59	1.66	1.53	0.55

Marginal effects calculated as discrete change from the base (period: 1968–1972; age: 0–9 years) of the expected farm fatality rate per 10,000 farm people. Statistical significance calculated from the standard errors estimated with the delta method. * ,* *,* ** denotes statistical significance at the 10%, 5%, 1% level, respectively.

reported that the fatality rate in Canada in the 1990–96 period was 11 times higher for men than women.

4.2. Cause of fatality

Regarding the cause of death, we focused on the three main factors that correspond to 84% of all the fatalities and aggregated all the other categories in the heterogeneous group ‘other cause’. Notice that within this residual category, 40% of fatalities are due to slurry and 29% to electrocution.

In terms of overall trend, three observations can be made. First, the overall reduction of the fatality rate over time is ascribable to other cause and especially to vehicles and equipment. Specifically, the fatality rate for vehicles and equipment exhibited the most substantial decrease. As shown in Fig. 3, between the end of 1960s and for most of the 1970s the fatality rate ranged between 1.0 and 1.3. In contrast, after 2008 the fatality rate is just 0.5. Moreover, as shown in Table 4 the reduction in the fatality rate for vehicles and equipment and other causes started to be statistically significant in 1980s and especially after 1998, basically as reported for the overall trend. Besides, Table 1 shows that the fatality rate due to vehicles and equipment in NI in the last decade has been one of the lowest across developed countries.

Second, the analysis allows to identify that there is an overall increase of the fatality rate over time for animal related accidents. For animal, fatality rates exhibited a growth from the end of 1960 s with the most marked increases in recent years. Previous studies indicated a procyclical association between business cycle indicators and the incidence of non-fatal accidents in mining construction, and manufacturing, but not in agriculture and trade (Pouliakas and Theodossiou, 2013). In contrast, our results indicate that the positive relationship between fatality rate and the sectorial expansion can also be present in agriculture outside the short-term fluctuations. Overall, this suggests that while fatalities due to vehicles and equipment have reached a flattening baseline, statistical indications are that farm deaths related to animals may still increase in the future.

Third, no statistical recognizable time trend is detectable for falls to indicate that this type of fatalities are less related to the growth of the sector and improvements of safety standards and more a persistent accidental occurrence of the farming activity. This is relevant considering the relatively high incidences of deaths due to falls in NI as shown in Table 1.

Regarding age, Fig. 3 and Table 4 confirm that the overall trend described in the previous section is common across all the types of deaths apart from *other cause*. Specifically, for other cause the fatality rate has a peak at 20–29 years and after that it decreases with age. In general, other cause involves the youngest group of individuals (28 years), followed by vehicles and equipment (41 years), falls (47 years), and animals (60 years).

4.3. Seasonality

With regard to seasonality, the bottom row of Table 4 indicates that fatality rates are the highest around mid-year and the lowest at the beginning/end of the year when farming is less intense. For example, the fatality rate of the third quarter (1.80) is basically twice the fatality rate of winter (0.84) and autumn (0.95).

Moreover, mid-quarters are also the period of the year where the largest and most significant reduction in fatalities was observed as shown in Fig. 4. Conversely, no statistical increase in fatality rates was detected across all the quarters. In general, the overall decreasing trend in fatalities as a result of vehicles and equipment is concentrated in the mid-year seasons when more activities involving tractors and machinery are undertaken, i.e. silage and hay making. In contrast, the rise in deaths as a result of an accident involving livestock is more evenly distributed during the year, a consequence of the fairly constant animal handling activities across seasons in NI.

In terms of age, there is an inverse relationship with seasonality: youngest individuals are more likely to be involved in a fatal accident in the middle of the year while for the oldest individuals it is more at the beginning/end of the year. Specifically, the average age is 45 years in the first quarter, 40 in the second, 41 in the third, and 46 in the fourth. This may be linked to the busy farming activity around mid-year that requires a more intensive use of vehicles and equipment and that commonly involves younger individuals as discussed before. Indeed, increased intensity in day to day farming activity stimulates the labour demand in agriculture towards relatively younger workers as happens, for example, with students and the seasonal migrant labour in agriculture (Martin, 2016).

Fig. 4 and Table 4 also indicate that spring is the only quarter that mimics the overall trend in terms of improvement of fatality rates for young-middle age individuals, i. e. 10–49 years. This happened regardless of the cause of accident and sex of the injured person and it is due to the high incidence of deaths for very young individuals in this quarter that persisted over the years.[3] In general, spring is the season with the highest number of fatalities for 0–9 years (46%), followed by summer (30%), and winter/fall (12%). In this season, children can spend relatively more time outside and also parents have relatively less time for supervision them because of farming pressure (CDC, 1999).

4.4. Day of the week

The bottom row of Table 5 shows that the fatality rate has a clear path over the work week: starting from Monday, it increases almost continuously every day until Friday. Specifically, in the first three day of the week the fatality rate ranges between 1.35 and 1.37, it increases to 1.59 on Thursday and it achieves a maximum on Friday (1.66). Notice also that on Saturday the fatality rate is still high to indicate that farmers and non-farmers are intensively working 6 days per week. Sunday, exhibited the lowest fatality rate of the week being 0.55 per 10,000 farm based individuals, basically one third of what is observed on Friday. For comparison purposes, Arana et al. (2010) analysed the distribution of farm fatalities by week day in Spain in 2004–08 and indicated a similar uniform distribution from Monday to Saturday and 50% less accidents on Sunday.

Two interesting results related to age can be highlighted. Firstly, the increase of fatality rate with age occurred on Thursday, Friday, and Saturday to indicate that older farmers are still actively involved especially when the day to day farming routines increase. Secondly, the reduction of fatalities for the younger age individuals involves the end of the week and especially Sunday when farming is less intense. This suggests that farm fatalities involving young and very young individuals are due to the presence of these individuals when they are not in school (i.e. at weekends) and less to the lack of supervision by their parents due to farming pressure. The analysis by period confirms that fatality rates decreased at the end of the working week when farming is more intense.

5. Conclusions

Preventing farm related fatalities is challenging because of the unique nature of the agricultural work environment. In other industries, victims of occupational injuries are commonly workers aged 16–64. Due to the special nature of farms that are workplace and homes, children and the elderly are also casualties. In the last two decades, the efforts have been made by authorities in NI, GB, and around the world to improve farm safety have increased (Canadian Agricultural Safety Association, 2022; Farm Safety Australia, 2022; HSENI, 2020a). Nevertheless, fatality rates in agriculture are still high per se and if compared to the other industries. For this reason, understanding the evolution of farm fatalities over a long period of time is an important research focus to know what dangers farmers are exposed to and how they respond.

In this study, we applied an age-period model to study the evolution of farm fatalities in Northern Ireland between 1968 and 2017 by sex, type of accident, seasonality, and day of the week. With regard to the causes of accidents, although vehicles and equipment are still the primary cause of deaths on a farm, their incidence has decreased continually over time. Possible reasons for the decline may include improved safety standards, better driving skills, and an increased use of professional contractors. Moreover, since the beginning of 2000 s fatality rates of vehicles and equipment have become quite steady to indicate that a flattening baseline may have been reached. In contrast, deaths as a result of being injured by an animal have exhibited an increasing trend and may further rise in the future as a consequence of sectoral growth. Regarding age, the fatality rate has a U-shaped distribution skewed towards older farmers with the lowest incidence of deaths for middle age individuals. This path is consistent across genders although with differences. The distribution of accidents by week day also indicated that farm fatalities involving young and very young individuals is linked to the exposure of these individuals to farm dangers when they are not in school, i. e. Sunday. In contrast, older farmers are exposed to fatality risk when farming is more intense.

This paper contributes to the policy debate around reducing farm fatalities in two ways. First, the results are useful to identify where public policies should be directed. Specifically, this study suggests that policy makers should focus on three areas of intervention: potential victims, type of accidents, and sectors. In relation to those at risk of involvement in a fatal farm related accident, public policies should give priority to the risks associated with periods of intensive workloads for older farmers especially at the end/beginning of the year. From this point of view, family members and farmer's spouse can play a role to adhere to safety practices and promote the proper behavioural change (McLaughlin and Sprufera, 2011). Secondly, awareness is needed of the risk to young children if they are helping their parents on the farm at weekends and for the need for proper supervision around tasks they may be undertaking and the implementation of good safety practices. Pre-summer awareness campaigns may be useful to reduce the persistently high fatality rate of extremely young individuals.

In terms of the type of accident occurrences, public policies should increase farmers' awareness around farm risks associated with two specific causes of death, namely falls and vehicles. Regarding falls, the results indicated that no time path is recognizable in over fifty years of data. In other words, this type of fatalities is more a structural occurrence of the industry and not the result of sectorial trends. This is particularly important in NI given the relatively high incidence of this type of accidents in the region as shown in Table 1. Effective interventions should increase awareness around the dangers for working on a fragile roof, near roof lights, open edges, and platforms with the aim to promote the use of specialist equipment when operating at heights, warning signs, protective guard rails, and safety nets. Similarly, public policies should stress the use of personal protective equipment such as ATV helmets, increasing awareness of risks associated with poor visibility when driving, and promoting safety training for farm vehicles. The focus should be on the risk of accidents due to vehicles and equipment in spring and summer.

At the sectorial level, the association between the increase in fatality rate due to animals and the expansion of beef and dairy sectors that has occurred in the last three decades indicates farmers employed in these industries can be exposed to a higher fatality risk in the future. This suggests that public policies designed to promote positive reinforcement of safety behaviours and practices when operating with animals can be particularly effective in these sectors. For example, safety training around all the aspects of animal handling could be made mandatory in order to access and receive public schemes and grants.

The second contribution of this research is to help policy makers to quantify the cost of farm fatalities. Several approaches are employed by public authorities to monetise the cost of human life. In the UK, HSE has employed the so-called value of statistical life (VSL, HSE, 2022; Transport Research Fundation). This method consists on estimating the willingness to pay (WTP) for reducing the number of deaths of 1 via elicitation of individuals' preferences towards different accident profiles, i. e. combinations of injury severity and probability of the

[3] In spring, the fatality rate of 0–9 years was higher than the fatality rate of 10–49 years by 1.16 for vehicles and equipment, 0.16 for other cause, and 0.10 for fall. In contrast, the rest of the year reported a modest improvement of the fatality rate only for fall (0.15). Similar differences are observed by gender. Over the years, 0–9 year fatality rates decreased in every season apart from spring that increased until mid-nineties.

treatment outcome. Once estimated WTP, VSL is calculated as the weighted average where WTP of each accident profile is multiplied by the probability to occur. From this point of view, the fatality rates estimated in this study can be used to calculate the VSL specific for the agricultural sector as a whole and differentiated by gender, cause of accident, seasonality, and day of the week. This can help policy makers to assess more effectively the cost of human life in agriculture.

The case study of this paper is Northern Ireland, a region of the UK with a relatively large agricultural sector and farm population (DAERA, 2021a). Despite the differences in farming structure and scale across countries, similarities in terms of magnitude and typology of fatality rates allow to contextualise and extend the policy implications of this study to other regions. Moreover, our results can be extended to other countries with disparities of health and safety standards across farms and that are interested in promoting farmers' safety.

CRediT authorship contribution statement

Simone Angioloni: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Claire Jack:** Conceptualization, Resources, Writing – original draft, Writing – review & editing.

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Appendix A

See Appendix Tables 1A–3A here.

Table 1A
Cohort analysis for grouped and ungrouped data.

		Ungrouped Data (4550 observations)[a]			Grouped Data (90 observations)[b]		
Sample	Model	LLF	CC[c]	BIC	LLF	CC[c]	BIC
Men	APC	-1518.61	0.01	3180.41	-200.59	0.13	477.67
	AP	-1525.77		3169.47	-209.36		481.71
Women	APC	-192.83	0.02	528.84	-60.15	0.08	196.80
	AP	-195.68		509.28	-62.90		188.79
Vehicles	APC	-975.13	0.00	2093.45	-154.24	0.06	384.97
	AP	-976.75		2071.41	-156.91		376.81
Fall	APC	-454.66	0.02	1052.52	-108.55	0.11	293.60
	AP	-460.23		1038.38	-113.95		290.89
Animal	APC	-279.83	0.02	702.86	-72.14	0.07	220.79
	AP	-283.53		684.99	-74.88		212.76
Other	APC	-384.97	0.00	913.13	-90.99	0.01	258.48
	AP	-385.11		888.15	-91.26		245.52
Jan-Mar	APC	-390.33	0.01	923.85	-99.88	0.03	276.26
	AP	-392.00		901.92	-101.15		265.29
Apr-Jun	APC	-697.51	0.00	1538.20	-138.21	0.05	352.91
	AP	-699.02		1515.96	-141.17		345.35
Jul-Sep	APC	-705.20	0.00	1553.59	-136.92	0.04	350.34
	AP	-707.10		1532.12	-138.89		340.77
Oct-Dec	APC	-418.62	0.02	980.43	-95.48	0.18	267.45
	AP	-425.43		968.78	-102.60		268.20
Monday	APC	-169.35	0.02	481.89	-56.64	0.09	189.77
	AP	-172.59		463.11	-59.76		182.52
Tuesday	APC	-363.59	0.00	870.38	-101.95	0.03	280.40
	AP	-365.05		848.02	-103.56		270.13
Wednesday	APC	-360.63	0.01	864.45	-98.49	0.04	273.48
	AP	-362.52		842.97	-100.37		263.74
Thursday	APC	-357.13	0.01	857.44	-98.18	0.06	272.85
	AP	-360.58		839.08	-101.35		265.69
Friday	APC	-408.44	0.01	960.06	-102.38	0.05	281.26
	AP	-410.28		938.47	-104.68		272.36
Saturday	APC	-412.80	0.01	968.79	-95.70	0.11	267.89
	AP	-417.61		953.14	-100.55		264.10
Sunday	APC	-397.59	0.00	938.36	-99.36	0.02	275.23
	AP	-398.26		914.44	-100.01		263.02

[a] based on 91 age classes from 0 to 90 and 50 period classes from 1968 to 2017.
[b] based on 9 age classes and 10 period classes as described in Section 3.
[c] Cohortality coefficient based on the deviance statistics as described in Chauvel et al. (2016). The APC model is based on natural cubic splines with 6 interior knots for age, 5 for period, and 3 for cohort as in Sasieni (2012). The AP model sets to 0 interior knots for the cohort effects. The APC model was estimated with a drift at cohort-period level while the AP model was estimated with a drift at the period level.

Table 2A
Model estimates for sex, cause, and season.

		Sex				Cause								Season							
		Men		Women		Veich. & Equip.		Fall		Animal		Other Cause		Jan-Mar		Apr-Jun		Jul-Sep		Oct-Dec	
	Variable	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Period	1973–1977	0.06	0.21	-1.73	1.07	0.20	0.20	-0.53	0.55	0.83	0.66	-0.47	0.38	-0.41	0.44	0.12	0.31	-0.20	0.28	0.55	0.37
	1978–1982	-0.06	0.21	0.36	0.53	0.01	0.21	-0.06	0.50	0.91	0.78	-0.28	0.40	-0.10	0.41	-0.04	0.33	0.05	0.27	-0.06	0.44
	1983–1987	-0.28	0.22	0.28	0.56	-0.44	0.25	-0.02	0.50	1.12	0.88	-0.08	0.40	-0.19	0.43	-0.13	0.34	-0.10	0.28	-0.31	0.48
	1988–1992	-0.54	0.24	-1.46	1.07	-0.45	0.25	-0.83	0.59	0.92	0.79	-1.15	0.35	-0.56	0.49	-0.24	0.35	-0.96	0.38	-0.28	0.48
	1993–1997	-0.12	0.22	-1.35	1.07	-0.31	0.24	-0.23	0.52	1.35	0.64	0.13	0.33	-0.25	0.44	-0.01	0.33	-0.24	0.30	0.28	0.41
	1998–2002	-0.95	0.27	0.50	0.56	-1.09	0.32	-0.41	0.55	1.38	0.72	-1.34	0.61	-0.91	0.57	-1.56	0.55	-0.33	0.31	-0.39	0.50
	2003–2007	-0.52	0.25	-0.04	0.69	-0.82	0.30	-0.66	0.59	2.17	0.66	-0.92	0.45	-0.80	0.57	-0.35	0.38	-0.41	0.33	-0.12	0.48
	2007–2012	-0.51	0.25	0.32	0.63	-0.99	0.33	0.09	0.52	1.66	0.75	-0.44	0.41	0.17	0.42	-0.08	0.37	-0.96	0.42	-0.40	0.53
	2013–2017	-0.66	0.26	-0.41	0.80	-0.95	0.32	-0.52	0.58	1.83	0.61	-1.15	0.42	-0.24	0.46	-0.53	0.40	-1.01	0.42	-0.12	0.48
Age	10–19 years	-0.70	0.23	-0.57	0.52	-0.13	0.23	-0.74	0.47	-16.99	0.79	-1.19	0.45	-0.21	0.47	-1.12	0.33	-0.04	0.29	-0.50	0.52
	20–29 years	-0.40	0.22	-1.26	0.75	-0.34	0.25	-1.20	0.57	0.07	0.84	0.20	0.27	-0.22	0.49	-0.56	0.29	-0.02	0.30	0.05	0.46
	30–39 years	-0.53	0.23	-1.18	0.75	-0.33	0.26	-0.50	0.47	-1.27	1.23	-0.22	0.30	-0.25	0.52	-0.85	0.34	-0.12	0.32	0.05	0.48
	40–49 years	-0.67	0.25	-1.10	0.75	-0.37	0.28	-0.43	0.47	-16.70	0.79	-0.66	0.45	-0.17	0.52	-1.04	0.38	-0.59	0.39	0.26	0.46
	50–59 years	0.41	0.21	-1.00	0.75	0.66	0.21	0.66	0.41	1.03	0.81	-0.19	0.36	0.64	0.43	0.16	0.26	0.66	0.28	0.95	0.40
	60–69 years	0.48	0.21	0.07	0.52	0.51	0.23	1.08	0.43	1.99	0.74	-0.94	0.47	1.38	0.38	0.33	0.30	0.44	0.31	0.75	0.44
	70–79 years	1.06	0.21	-0.19	0.56	0.78	0.24	1.31	0.35	2.42	0.74	-1.22	0.64	0.53	0.52	0.52	0.28	1.16	0.28	1.65	0.40
	80 +	0.99	0.29	-1.27	1.03	0.61	0.34	-0.18	0.77	2.15	0.81	-16.43	0.40	0.90	0.59	0.22	0.42	0.51	0.46	0.65	0.66
	Constant	-8.35	0.20	-9.66	0.42	-9.33	0.20	-10.31	0.43	-13.17	0.86	-9.97	0.34	-9.39	0.39	-8.18	0.27	-8.51	0.26	-9.66	0.41
	LLF	-200.6		-60.6		-107.5		-154.1		-73.9		-85.28		-99.45		-134.7		-134.2		-104.5	
	Observations	90		90		90		90		90		90		90		90		90		90	

Table 3A
Model Estimates for week day.

		Monday		*Tuesday*		*Wednesday*		*Thursday*		*Friday*		*Saturday*		*Sunday*	
	Variable	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Period	1973–1977	-0.09	0.74	0.66	0.52	0.07	0.40	-0.43	0.42	0.14	0.32	-0.60	0.43	1.55	1.12
	1978–1982	-0.89	0.79	0.23	0.58	-0.24	0.45	0.28	0.35	0.12	0.33	-0.19	0.39	0.96	1.22
	1983–1987	0.44	0.69	0.65	0.53	-0.22	0.45	-0.59	0.45	-1.15	0.50	-0.50	0.43	2.08	1.08
	1988–1992	-0.54	0.74	0.28	0.58	-0.19	0.45	-0.71	0.48	-1.34	0.55	-0.60	0.45	0.32	1.41
	1993–1997	-0.03	0.67	0.47	0.56	-0.15	0.45	-0.41	0.43	-0.77	0.44	0.19	0.35	1.73	1.12
	1998–2002	-0.81	0.78	0.64	0.54	-0.80	0.57	-0.85	0.51	-2.69	1.02	-1.37	0.63	1.99	1.10
	2003–2007	-0.18	0.80	0.98	0.52	-0.68	0.57	-0.96	0.56	-1.19	0.55	-0.74	0.51	1.19	1.23
	2007–2012	-0.19	0.77	0.53	0.58	-0.62	0.57	-0.34	0.45	-1.14	0.55	-0.49	0.48	1.25	1.23
	2013–2017	-1.42	0.98	0.07	0.65	-0.44	0.53	-0.39	0.45	-0.62	0.44	-1.22	0.63	1.59	1.16
Age	10–19 years	-0.02	0.55	-0.46	0.48	-0.73	0.43	-0.35	0.49	0.03	0.45	-1.02	0.47	-1.41	0.79
	20–29 years	0.47	0.50	-0.34	0.48	-0.60	0.43	-0.20	0.49	-0.15	0.49	-0.20	0.38	-1.98	1.06
	30–39 years	-0.45	0.68	-0.41	0.51	-1.45	0.63	0.29	0.45	0.25	0.46	-0.36	0.41	-1.90	1.06
	40–49 years	0.12	0.58	-1.41	0.77	-0.84	0.51	-0.54	0.59	0.23	0.48	-0.84	0.51	-1.10	0.79
	50–59 years	0.82	0.56	0.34	0.44	-0.14	0.41	1.02	0.40	1.07	0.40	0.15	0.38	0.28	0.52
	60–69 years	0.76	0.54	0.78	0.41	0.32	0.38	1.00	0.41	1.17	0.40	-0.08	0.43	-0.38	0.68
	70–79 years	1.76	0.69	1.25	0.40	0.33	0.43	1.41	0.41	0.92	0.47	0.81	0.37	0.28	0.61
	80 +	0.86	0.73	0.05	0.77	0.43	0.56	0.67	0.66	1.30	0.55	-0.96	1.03	0.33	0.79
	Constant	-8.87	0.81	-9.46	0.49	-8.35	0.34	-8.78	0.38	-8.65	0.37	-8.18	0.32	-10.70	1.04
	LLF	-98.35		-98.29		-100.96		-99.08		-97.44		-95.25		-57.44	
	Observations	90		90		90		90		90		90		90	

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