A Farm Safety Model for Irish Farms

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Abstract
While farming in Ireland accounts for 6% of the workforce, statistics illustrate that farming accounts for on average one third of workplace fatalities in Ireland. In total, 179 people have lost their lives on Irish farms over the last ten years. For every fatal accident that occurs on farms, many more non-fatal accidents occur resulting in injuries of varying severity. The statistics portray an image of a sector, which has a significant health and safety problem. It is also a sector in the Irish economy in which very little research in health and safety has been undertaken. Several models of health and safety on farms have been put forward over the years from a range of disciplines, while each model has elements that apply to farm safety in Ireland, none are complete. The aim of this paper is to develop and present an Irish Farm Safety Model, particularly oriented towards farm safety at farm level in Ireland. The research establishes that there is a dynamic relationship between people, the environment and technology in farming which is fundamental to health and safety on the farm. It also concludes that stress and the broader environment are influencing factors. The Irish Farm Safety Model (IFSM) provides an understanding of the factors which impact on farm safety through farmer, farm environment and farm technology interactions. It therefore suggests that a trichotomous rather than a dichotomous model is best in explaining farm safety in the Irish situation.

Keywords: Health and safety, farm accidents, mortality, injury
**Introduction**

Primary Agriculture in the Republic of Ireland in 2005 accounted for 5.7% of total employment. Yet the sector accounts for an average of thirty per cent of workplace fatalities. The Health and Safety Authority (HSA) regard the Irish farm as one of the most dangerous workplaces in the country with almost eighty fatal accidents in the last ten years (HSA, 2006). Several studies have examined the incidence of farming accidents in Ireland. Doyle (1988) found that on systematic examination of hospital and general practitioner records, it was estimated that roughly 3,000 farm accident cases are seen in Irish accident and emergency departments annually and at least 2,500 in general practice. A survey of farmers by McNamara and Reedy, 1992 found that between 1987 and 1991, an average of 5,000 accidents occurred annually, this figure decreased to 2,000 for the five-year period 1992-1996 (McNamara & Reidy, 1997). McNamara and Reidy, 1997 estimated that including those persons providing on-farm services and non-working family members, up to 600,000 persons are exposed annually in one way or another to the hazards of farming.

The statistics portray an image of a sector, which has a significant health and safety problem. The situation is similar in other countries. Agriculture is reported to be one of the most hazardous industries in America. Rautiainen and Reynolds, 2002 reported that during the 1990s the fatality rate in farming was approximately 22/100,000 workers. An analysis of agricultural fatalities between 1980 and 1985 showed that agricultural production has a fatality rate more than three times that for all industries combined. Myres and Hard, 1995, cite three data sources which estimate fatality rates in agriculture ranging from 17 to 42 deaths per 100,000 workers which puts agriculture as one of the most hazardous industries in America.

Similar to America, agriculture in Finland has been described as one of the most hazardous industries with a fatality rate of 6.5/100,000 workers (Rautiainen & Reynolds 2002). Sweden also reports a high level of fatal accidents in agriculture, 11.6/100,000 workers per year (Thelin, 2002). Research indicates that workers in one Swedish municipality found that farmers displayed the highest work-related injury level. Agricultural injury in Australia represents a significant health, social and economic issue. It is the fifth most dangerous occupation in Australia with a fatality rate of 19.5/100,000 employed compared to 5.5/100,000 for all employees (Mather & Lower, 2001).

**Definition of an Accident and Injury**

Many accident definitions exist, from very complex concepts to the more straightforward. Heinrich (1941) defined an accident as an event in which the contact or exposure of a person with an object, substance, another person or conditions causes personal injury or suggests the probability of such injury. Similarly the World Health Organisation defines an accident as an event that results or could result in an injury (WHO, 1989). Both definitions indicate the distinction between accident and injury, accident being the event and injury being the outcome. Strasser et al., 1981, extends the concept of an accident by including outcomes other than injury in the definition and adds another dimension to the accident definition, which is that accidents are unplanned. *An accident may be thought of as an unplanned act or event resulting in injury or death to persons or damage to property* (Strasser et al., 1981, p.4).

The most widely referenced definition of injury is that proposed by Baker et al., 1984, which defined injury as a bodily lesion which results from acute exposure to amounts of energy (mechanical, thermal, electrical, chemical or radiant) that exceed the threshold of physiological tolerance.
**Purpose of the Paper**
Several models have been put forward over the years from a range of disciplines, which aim to explain why accidents and injuries occur. All of these models include a time dimension, while some include social and societal level analysis. While each model has elements that apply to farm safety in Ireland, none are complete. The aim of this paper therefore is to develop and present an Irish Farm Safety Model, which incorporates the critical elements contributing to farm accidents in Ireland. The model can then be used by advisory and other services as a means of reducing the high levels of accidents and fatalities on Irish farms.

**Materials and Methods**
1. The first component will draw on an array of material and models presented in the literature, capturing elements that are particularly important for the Irish situation.
2. A survey of 1119 farms in the republic of Ireland which examined accidents and fatalities on farms as well as farm characteristics and human practices and attitudes towards farm safety.
3. Detailed case studies of 9 farms representing different risk categories, where farms were inspected and assessed and the operator’s views and opinions sought on different risk elements identified.

**Literature Review of Models of Accidents and Injury**
Accidents arise from circumstances in the workplace which are created by man's interaction with technology and the farming environment. According to Andersson (1999) the word causation is central to the accident concept as all accidents include a time dimension. The genesis of an accident can be explained as a series of causal and mutually interrelated mechanisms (‘upstream’), which can be explained at various distances in time and at various social and societal levels. Similarly, Strasser et al., 1981 include a time dimension in their perspective on why accidents occur. They view an accident as a complex sequence of events representing a break down in the proper interrelationship of man and his environment. For man, an accident is a manifestation of his inability to adjust to given conditions or circumstances within the environment (Strasser et al., 1981, p.23). Several models have been put forward over the years from a range of disciplines, which aim to explain why accidents and injuries occur. All of these models include the time dimension discussed by Andersson (1999), while some include social and societal level analysis. The models can be divided into three main types 1) linear stage models, 2) Surveillance models and 3) Systems-oriented models. The linear models view accident causation mechanisms as a linear flow of time-ordered stages or events. Heinrich, with an industrial background was the first to present accident causation visually. He developed the ‘Domino’ model which is seen as five dominos in a row representing the environment which exerts an influence on human activities which give rise to hazards which in turn result in accidents which lead to injury. At the same time the public health field applied the epidemiological model to accident and injury situations. This model was initially developed from the perspective of infectious diseases and has been widely used and referred to by many researchers. The model illustrates the interaction between Host (human), Agent (hazard) and Environment. Haddon (1980), however, went further and developed a model for epidemiological research. The resulting model is known as the Haddon matrix. Haddon viewed the model as an aid to identifying preventative measures rather than for understanding the exact causes of accidents and injuries. The Haddon matrix provides a holistic view of the accident scenario and
options for prevention are easily identified. It has been widely used in many areas including that of traffic accident prevention.

Surveillance models are being developed to ‘support the development of preventative-oriented classifications, and to act as mental maps for data recording and analysis’ (Andersson, 1999, p.21). These models reflect a multivariate approach to collecting, compiling and analysing information which results from in-dept analysis of accident scenarios. These models portray the “triggering event” e.g. slip, “the contact event” e.g. cut and often “intermediate events” e.g. fall. The Swedish ISA model was the earliest prevention-oriented computerised system on injuries.

Systems-oriented models examine ‘mutual and complex interactions in virtually all types of applications from technology and biology, to economy, psychology and sociology’ (Andersson, 1999, p22). Other systems models were developed based on the theory of homeostasis or equilibrium. When a system is in balance it is found to be running according to how it was designed, however disturbances result in a loss of balance within the system. The West Jutland study on prevention of farm accidents (Glasscock, 1999) was initiated in 1992 and closed in 1997. The work resulted in the following model and the application of training based around these issues resulted in significant reductions in accident levels.

![Diagram](image.png)

**Figure 1.** The West Jutland study of farm accidents–model of farm accidents

The fundamental essence of all of the above models is that they provide a means to examine the elements, which comprise an accident event. Each model seeks to identify the causal mechanisms, which result in accident occurrence and thus provide opportunities for intervention. An examination of the interactions within a particular system is fundamental to this process.

**Characteristics of farming which impact on health and safety**
Farming has many unique factors which from a safety point of view, place those involved in the sector in a unique position compared to those in other sectors (McNamara & Reidy, 1997). While agriculture thinks and acts like industry, health and safety problems are not comparable.
The inherently dangerous characteristics of farming are widely acknowledged by farm health and safety professionals. In contrast to other industries farming has many characteristics which prove challenging to the management of health and safety. Doyle and Conroy (1989) compared the industrial working environment where working hours are limited and the worker is supervised to that of the farm where farmers work long hours to complete tasks alone. In addition deteriorating economic conditions increase the probability that farmers will cut corners with regard to health and safety in order to save money (Walsh, 2000). Accordingly, this ‘make do and mend’ approach results in increased risk of both injury and farm work-related ill health.

**Conceptual Framework**

From the literature review, it is possible to derive a conceptual framework regarding workplace health and safety. The complexity of the working environment is fundamental to the study of workplace accidents and subsequent injury. According to Dunne (2001) creating safer workplaces begins with establishing how dangerous the workplace actually is. The working environment, while fundamentally impacting on health and safety requires human interaction in order to give rise to the conditions in which accidents occur and injuries result.

![Conceptual framework](image)

*Figure 2. Conceptual framework for the study of health and safety on Irish farms.*

Figure 2 illustrates that the interaction of the person within the working environment is central to health and safety in the workplace. This relationship is of significant importance for understanding both the genesis of accidents in the workplace and also for studying the resulting injuries. While it is necessary to have an understanding of the environmental factors which negatively impact on health and safety and similarly the person factors, the interaction of both the person and environmental factors is critical.

**Survey Results**

The design of the questionnaire was based on those used previously by Teagasc (The Irish Research/Extension System) in the ‘Survey of Health and Safety’ 1992 and 1997. Use of a similar questionnaire allowed for the examination of trends across the three survey periods. It also meant that one could use a previously validated instrument. The survey sample was that used for The National Farm Survey, which is a statistically weighted sample representing farmers in Ireland. Data were recorded for 1119 farms. Analysis of the data took place at two
levels, that of the entire population (n=1119) and the sub population that experienced an injury (n=110).

A farm work related injury was found to have occurred on 9.8% (n=110) of the sample farms. When the relevant weighting factors were applied to the sample, the results indicated that an estimated 3,002 injuries occurred on Irish farms in the most recent survey year 2001. This represents an injury rate of 21.5/1000 for Irish farmers.

Environment factors
The impact of seasonality on injury occurrence appears, from the results to be complex. Not only does seasonality impact on injury occurrence in the individual farm systems, but there also appears to be a seasonal effect on accident type. The majority of tillage accidents were reported in autumn and summer, which are undoubtedly the busiest times on Irish tillage farms. From the results, it is apparent that injury occurrence while influenced by season is more closely associated with the level of activity underway at particular times of the year on the farm.

System of farming emerges as an important determinant of the environmental consequences of farming. Seasonality, time of day and location of accident occurrence are all factors of the system of farming. In this study, all of those injured were members of the immediate or extended farm family. The farmer is at the highest risk of injury. No age group was exempt from injury, however, the young and old present particular concerns. The highest proportion of injuries were sustained by the 17-34-year-old age group, yet according to (CSO, 2002), this group accounted for the smallest proportion of Irish farmers in 2001. Based on these findings, it is reasonable to suggest that these young farmers did not experience positive safety socialisation into farming. Those over 65 years old accounted for one in ten of the injuries reported in this study. Working with animals presented as the activity yielding most injuries and within this a wide variety of activities were reported. When compared to the results found in 1997, it would appear that twice as many accidents occur now while working with animals than did previously.

Human factors
While the majority of farmers in the study classified farming as dangerous, they classified their own farm as safe. This suggests that farmers are aware of the hazards associated with farming and can identify them on other farms; however they do not recognise the hazards present on their own farm. Similar conflicts were observed by Elkind, 1993. Although the majority of respondents considered their farm to be tidy, the high proportion of trip and fall injuries occurring in the farmyard suggest that general housekeeping and tidiness is an issue on many farms. Noise is not perceived to be a hazard by Irish farmers despite the fact that farmers as an occupational group suffer from noise induced hearing loss to a greater extent than other occupational groups (May, 1990).

On some farms children continue to engage in hazardous activities and many are allowed access to all areas of the farm. Because the farm and family home are often one and the same; children are injured both at work and at play on the farm (Murphy, 1992). In Ireland as with other countries, children are very much involved in farm activities and are often a valuable labour source on the farm. Children’s involvement in the family farm has traditionally very important as a business and way of life was being passed on from generation to generation.
Case Study Results

The case studies pursued in more detail the environmental factors elucidated in the survey. Various aspects of the working environment were found to be hazardous by the researcher and in most cases the farmer also recognised the hazard. However, in relation to cattle handling facilities, the research found that many farmers did not appreciate the hazardous nature of these facilities; this fundamental lack of awareness was not found in relation to any other issue during the course of the case study research. The research also highlighted that many of today’s problems were great solutions of the past, open slurry pit storage and asbestos roofs being two that were discussed in the interviews. These items often received significant grant aid to establish, but now require significant investment to make safe.

The case study interviews provided a deep insight into the knowledge, perceptions and attitudes of the farmers relating to health and safety on their farms and the key factors that influenced attitude formation. Through discussions about their own farm yards, the equipment they use and the activities they engage in, the interviews exhibited the varying knowledge and interest that exists among farmers in relation to the hazards associated with farming. The importance of safety as a part of farm work ranged from being an important feature to being vital. The level of discussion engaged in, in the interviews, reflected the level to which safety was examined and considered on the farm. Three of the case study farms engaged more fully on safety than the other cases. These were typically of a younger age and had large commercial farms. The three farms selected from the low-risk category did not engage in the same level of discussion as those from the other two categories. This possibly reflects the degree to which they are required to confront safety issues in their day-to-day work. While farmers are aware of the dangers associated with farming they do not consider their occupation dangerous. This indicates that there is a cultural belief in farming that it is a healthy and safe occupation. There is an almost passive acceptance of hazards, risks, illness and injury on many farms (Murphy, 1992). Farming is more than an occupation, it is a lifestyle. Although all the interviewees recognised and alluded to specific dangers associated with farming, as an occupation they did not perceive it as dangerous.

Quite varied views were expressed on accident prevention in the interviews. Literature suggests that farmers who believe that they have limited ability to prevent injury and ill health problems do not see the immediate benefit in taking precautions and are in fact less likely to take precautions (Wadud et al., 1998). Certain types of accidents were seen as being more preventable than others. Accidents involving children on tractors can be prevented if children are not taken on tractors. The case study research also highlighted the fact that while all of the factors discussed, independently have an impact on health and safety on the farm there is a synergistic effect of these factors on farm safety. A similar conclusion was reached by Murphy, 1992.

While the interaction of man and his working environment provide the context for the occurrence of occupational accidents, the case study findings illustrate the complexity of this interaction. This was quite clearly illustrated from the case studies in that farms where general farm management appeared to be good, the management of safety too was good. While all farms ascribed an importance to health and safety as part of their work on the farm, this was clearly not translated into actions on the ground. By and large these farmers knew and understood the hazards present on their farms and the risk associated with these hazards. However, in many instances the farmers engaged in the risk. Similarly, where PPE (Personal Protective Equipment) could be used to eliminate or minimise a risk, farmers often chose not to use them.
Irish Farm Safety Model (IFSM)

Many models in safety research are constructed to represent the process of accident occurrence and thus present options for prevention. These models focus on the genesis of accident occurrence rather than the factors, which generate risk in the environment. It is necessary to understand how unsafe behaviours, environments and social structures are created and how they can be changed to the better (Svanström, 1999).

![Irish Farm Safety Model (IFSM)](image)

**Figure 3.** Irish farm safety model (IFSM)

The IFSM provides an understanding of the factors which impact on farm safety through farmer, farm environment and farm technology interactions. It is within these components of the farm that risk is generated. The model construction is based on the dynamic relationship, which exists between the farmer, the farm environment and the technology employed on the farm, which were identified from the literature review, the survey and the case study research. The model evolved in three stages.

**Stage 1:** From a thorough review of the health and safety literature, a conceptual framework was developed. The literature review identified both the person and environment characteristics of farming which have an impact on health and safety. In addition, both the injury characteristics and the factors associated with injury risk related to either the person or the environment were identified. Thus, person and environment were identified as the fundamental components of a farm health and safety model. The interaction of the person within his/her environment was also identified as being central to health and safety. Thus a review of literature suggests a dichotomous model, focusing on the person and the environment, for health and safety on farms.
Stage 2: The incidence of injury and the person characteristics and working environment were examined using a survey approach. The findings illustrated the impact of injury on the person and the contribution of the working environment to injury causation. Further, specific person characteristics such as attitudes and perceptions were examined, as were attributes of the working environment. However, this discrete examination of person characteristics and the working environment yielded many contradictions between the respondents self reported perceptions and the reported characteristics of the working environment. It became clear that the interaction between the person and the environment was more of an interrelationship, rather than simply how man interacted within the working environment.

Stage 3: The case study research pursued the relationship between the person and the working environment. The work sought to establish the reality of this relationship, how both factors interact and the impact of the interaction on the management of farm safety and health. The results distinguished between the working environment and the technology environment that is employed in farming. In this sense, technology is assumed as the application of science to industrial or commercial objectives and thus includes machinery, livestock, and chemicals. The case study analysis found that the farmer, environment and technology are interrelated. Distinct factors specific to farmer, the work environment and technology interact during the course of work. It is within these interactions that the negative effects of individual factors result in negative safety outcomes and the positive effects ensure that activities are pursued without any negative consequences. Stress was identified in case study research as having a significant impact on all of these interactions to varying degrees. The case study analysis indicated that safety management acts as a moderator of the negative effects of these interactions.

Discussion and Educational Importance
The farmer is identified as the central component of the safety model. Interaction can take place between person and environment or person and technology, or between person and an environment/technology interaction. If interactions result in negative outcomes they can potentially cause harm or loss to the person. The consequences of interactions not involving the person are less significant than those that do. The perceptions, attitudes and beliefs held by people have a significant impact on health and safety. While this was established in the literature review, crucial contradictions were observed in the field work components of the research.

Farmers evaluate the danger on their own farms based on whether they experienced an accident or not. Risk perception at farm level is based on accident occurrence. The percentage of time spent farming has been associated with farm injury risk. The case study analysis highlighted the different perceptions that exist among farmers of their own workloads. The farmers spoke of periods of pressure, which in tillage farming, for example, can last up to two months. Farming as an occupation provides variable workloads, which are greatly influenced by the seasons.

The environment represents the actual workplace or the farm. The work environment is broader than just the farmyard. Farm work takes place at locations other than farmyards, which include fields, homes, public roads and forested lands. The case study findings illustrated the level of integration that exists on some farms between the actual home and the farm, which, in many cases have no physical division. Environmental characteristics were identified in the literature as being associated with an increased level of risk on the farm. Both the size and system were found to be significantly associated with injury on Irish farms in addition the site and farm layout and farm facilities were identified as factors impacting on farm safety. Larger
farms are higher risk environments. The size of the farm will inevitably determine the level of a particular work activity. Farm size also impacts on the level of farm technology. The case study research suggests that farmers and employees on larger farms do indeed have a greater exposure to risk in their work environment. However, that is not to say that smaller farms are without risk. A similar situation to that presented by Murphy, 1992 was observed in the case studies in that smaller farms were frequently working with older technology, in an older environment which was sometimes less well maintained than that of larger farms. In addition, they may have a limited budget for farm improvements and often have a lower level of management skills.

No distinction was made between the environment and technology in the literature or the accident models reviewed. However, the case study findings reflected a distinction between the environment and other components of the farm, such as machinery, chemicals and livestock, which have an impact on farm health and safety. These elements have been collectively grouped as technology for the purpose of the model. The farm environment is one that has become progressively more technology intensive and will continue to do so into the future. Technology was differentiated from the environment after the case study analysis as the importance of equipment, chemicals and livestock as factors in farm health and safety became more apparent.

The case study findings indicate that stress is a person factor that has an impact on health and safety. However, the literature suggests that while stress impacts on work activities, the working environment and associated activities may in fact have an impact on stress. The relationship between stress and injury is complex in its very nature. Deliberate unsafe acts characterized by risk taking can result from a single stressor, time pressure, for example. In this situation the stress is not of the magnitude that results in reduced capabilities, however, reduced cognitive abilities or errors can also give rise to accidents through this mechanism. In addition, stressful working conditions may result in increased injury risk for those that are not themselves stressed. Neglecting safety rules or failing to tidy up in a stressful work environment causes hazards for others (Glasscock, 1999). In terms of the dynamic that exists between the farmer, environment and farm technology the IFSM illustrates the interaction between this dynamic and stress. Weather, time pressure and machine breakdowns are single stressors, which occur within the farmer, environment and farm technology trichotomy and consequently impact on stress and risk taking. Other stressors such as financial worries, family pressures and business management pressures do not necessarily occur within the safety trichotomy, yet over time they may have an effect on cognitive abilities. Thus stress is found to have a reciprocal relationship to the interactions within the safety trichotomy.

The case study analysis indicates that safety management on the farm is a function of farm management and the farmer’s ability to manage successfully. It appeared that where the skills were present to allow for successful management of the farm business they were also applied to the management of safety. Literature implies that although safety is a function of management, farmers do not have the skills required to adequately manage health and safety on their farms. However, the skills that are required for the successful management of health and safety are no different to those required for successful farm management. When safety is part of a groups norms and culture, irrespective of individual tendencies toward risk taking, individuals will be more likely to conform and work safely (Dunne, 2001). According to Lindsay, 1992 the creation of a positive safety culture helps achieve high safety standards. Traditionally farming in Ireland has not had a positive safety culture and thus safety was not identified as an important and rewarding element of farm management.
To date farm safety has not been a priority area for extension services, however extension services and support services to farmers are gradually becoming more involved. It is clear that farm safety is an integral component of farm management and the conditions that prevail on the farm. Where information and training on farm safety has been provided it has resulted in the reduction of accident levels. Farmers in Ireland are by law now required to carry out a safety assessment of their farms and farming activities. It is critical that health and safety be an integral part of both the training of advisers and farmers and form a part of normal advisory service activities.

**Conclusion**

The IFSM represents the safety trichotomy, which exists on Irish farms. Within each component of the trichotomy there are factors that exert an influence on each other and on the other model components. The most significant interactions are the farmer – environment interaction and the farmer – technology interaction. Interactions between technology and the farm environment influence safety on the farm and lead to increased risk in the environment. These interactions may or may not involve the farmer. The interactions, which occur within the trichotomy and stress have a reciprocal relationship. The interactions between factors in the trichotomy as shown above exert an influence on stress and similarly stress can exert an influence on these interactions.

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