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# Applied Research for a Safer Future: Exploring Recent Job Accidents in Agriculture, Italy (2012–2017)

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**Abstract:** The issue of “safe working” has received increasing concern in recent years worldwide, especially in Europe. Several European countries developed specific strategies to ensure the safety of operators and the awareness on the potential risks that can emerge from a vast set of activities, including field activity in agriculture. Earlier investigations have lately investigated this topic, proposing quali-quantitative analysis applied to specific economic sectors. The present study focused on the working accidents occurred in agriculture over the last 6 years (2012–2017) in Italy. By exploring where and when injuries occurred, the socio-demographic profile of involved persons (including age, gender, nationality) and correlating these episodes to agricultural practices, the present paper reveals intrinsic patterns of safe (or unsafe) working conditions at a quite detailed spatial scale (administrative provinces) in Italy. Based on these results, training/educational programs should be planned to increase awareness of risks involving workers in agriculture. Future scenarios can be explored based on specific information dealing with risk factors and operating conditions at various working sites with the final objective to establish suitable technical, legislative and operational measures to reduce job accidents.

**Keywords:** job safety; territorial analysis; primary sector; indicators; Europe

## 1. Introduction

In recent years, job safety has been considered an emergent question in multi-disciplinary research across European countries [1]. Occupational injury rates in Europe significantly diverged through time [2], space [3], industrial sector [2,4,5] job type [6] gender [5–8] and age [2,5,6,8]. Nevertheless, further studies demonstrated more mixed findings, specifically regarding age and economic sector [7,9].

Several European countries have advanced well-defined regulations and policy strategies encouraging greater safety of operators and awareness of the potential risks which can emerge in distinct working sectors, such as in open-field activities [10–12]. For instance, several procedures on working places embody risky activities in agriculture and forestry, where serious injuries and fatalities can happen [13,14]. Legal obligations and national guidelines for the safety of workers recognize the correct procedures for the correct use of machinery and tools [15]. However, detailed information is often overlooked by performing unsafe operations without responsiveness of probable hazards [10,11]. Therefore, a team of experienced and skilled operators is always required [12].

In the literature, quantifying job accidents is usually performed using classical methods and checklists [16–18], trying to register the most relevant information from each event, with the aim to identify and understand which factors interact together. For instance, the location where agricultural, forestry, garden maintenance and hobby activities occurred may outline several independent factors (e.g., environmental, geo-morphological): these drivers shape the overall exposure of a standard working operator and can even differ within different operators [16–21].

Based on these premises, this paper focuses on the professional accidents that occurred in the last 6 years (2012–2017) in the primary sector, considering Italian administrative provinces as the elementary analysis' spatial domain. While earlier studies have proposed some qualitative and quantitative approaches to analyze job accidents [22–37], a better understanding of this complex issue is imperative today since agriculture and forestry has lost workers and relative land in recent decades [18–21,38]. Today, agricultural land loss and abandonment, deforestation, excessive rate of land consumption and soil sealing are some of the foremost European challenges [39–43], possibly influencing safety conditions for agricultural jobs. The need to valorize the primary sector is thus pertinent for endorsing and preserving natural and rural landscapes [38,44–50], guaranteeing working safety at the same time [22,51,52].

Conceivable scenarios can be explored following risk factors and operating conditions at different working sites with the aim of establishing suitable technical, legislative and operational suggestions [14]. Some current studies focused on explicit issues that can be correlated with high-risk agricultural and forestry operations. First, courses and training in occupational safety should be planned and structured by employing definite class and practical models that suggest new and more advanced strategies promoting a safe working environment [53]. Second, the 2007 economic crisis and a worse-performing job market determined the increased fixed-term (or temporary) contracts in the European countries, especially in the ones most affected by economic recession, e.g., Mediterranean Europe [54]. With such background, temporary employees are often less practiced and unaware of risky operations. The widespread application of provisional work has raised worries about increased volatility of employment and the relative consequences for job quality and working conditions [55]. Third, farming and forestry subdivisions offer cheaper and fixed-term (often illegal) occupations to foreigners (e.g., immigrants). Their employees are frequently not informed about the hazards that they dealt with. Just to mention a relevant experience, a pilot research project was carried out in the Latium region in Italy, regarding the training needs for different foreign workers (e.g., from India, Romania) offering classrooms with native tutors. The main purpose was to disseminate useful information allowing for a better comprehension of the intimate relationship among risk perception of farmers and the key risks to which they are exposed [56].

Exploring job accidents that occurred following not only the location, temporal period but also the local socio-demographic profile of persons involved (e.g., by investigated the impact of age, gender, and nationality) and correlating these episodes with background agricultural and forest data, should provide useful and spatially differentiated information about safety work conditions. Moreover, future scenarios can be proposed resulting from a detailed analysis of inherent risk factors. Operating conditions in divergent working areas aims to establish suitable technical, legislative and operational strategies containing manifold job risks [14]. Without a thorough reflection on the specific job condition, the analysis of the impact of legal contracts and formal obligations on job risk in agriculture can be meaningless [55].

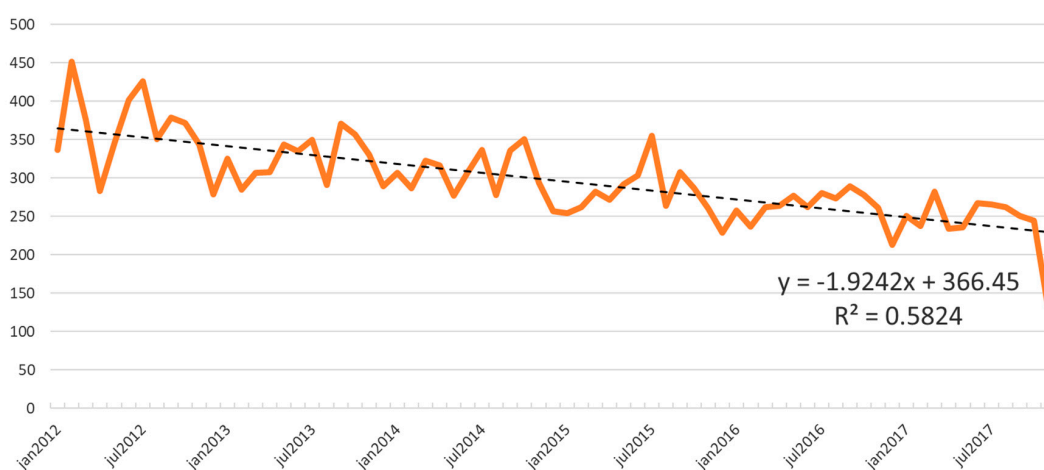
## 2. Materials and Methods

Italy has a long historic background in statistical reporting and analysis of accidents at work when compared to other European countries [57]. Thanks to the National Institute of Insurance (INAIL) founded in 1883, compulsory insurance against accidents at work was enforced in 1946, covering all types of employees. The dataset elaborated in this study derived from elementary data concerning accidents that occurred in Italy between 2012 and 2017. The present paper focused on the primary

sector, which can be divided into three basic economic activities: (i) cultivations and production of animal products, hunting and related service activities; (ii) fisheries and aquaculture; and (iii) forestry. Such a dataset permits the analysis of the following matters: (i) when an accident occurs; (ii) its main consequence for workers (fatal or not); (iii) age, gender and nationality of the involved worker. Aggregated statistics were managed in an ArcMap environment, GIS (Geographic Information System) software from ESRI, which allowed spatially explicit analysis of relevant indicators. With GIS tools, it was possible to detect where the highest number of events occurred in Italy. The spatial unit of analysis was the administrative province. The scale is chosen because INAIL does not provide more detailed information about the area where the critical event occurred, to assure protection of personal data according to the European statistical regulation on privacy. However, the month and year when the event occurred is provided. Such information is essential for correlating existing agricultural and forest circumstances with potential dangers in a defined area. Further indicators were collected. They are available in the most recent agricultural census (2011) available from the Italian National Statistical Institute (ISTAT) database. Integrated variables allowed a description of basic characteristics of the rural sector (e.g., utilized agricultural area). Consequently, two datasets were correlated using statistical techniques. A Principal Component Analysis (PCA) was run on the indicators' matrix, with the final objective to recognize similarity patterns among Italian provinces, demonstrating spatial trends in work accidents, mainly based along a north-south geographical gradient.

### 3. Results

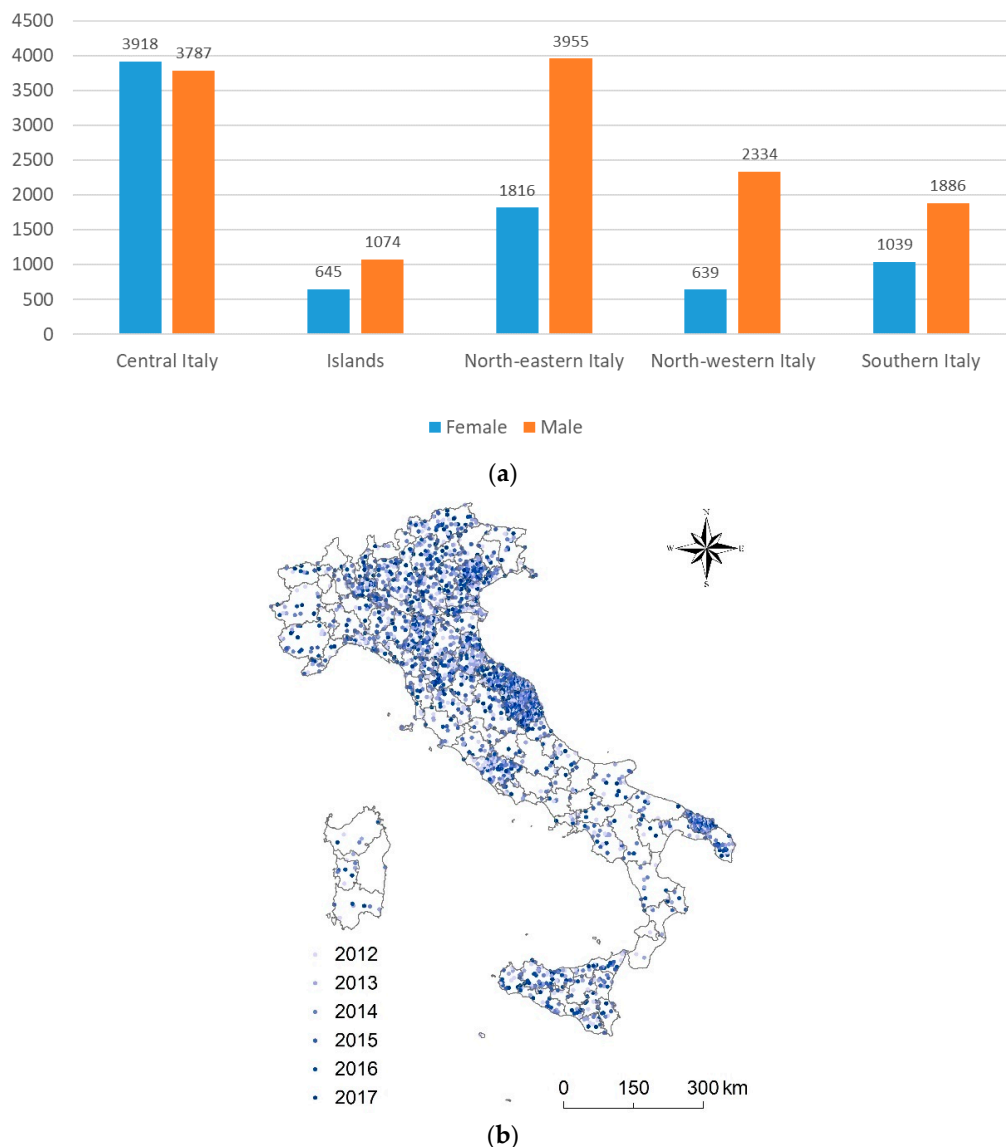
Following the study period (2012–2017), the empirical analysis presented has focused on the different characteristics emerging from recorded injuries in the primary sector (Figure 1). In Italy, nearly 21,100 accidents at work occurred in the past 6 years, including about 100 fatalities. The amount of injuries (including the fatal ones) has followed a declining trend over time. Such tendency can be influenced by a more effective dissemination of technical information to workers through specific courses/training on safety at work being compulsory in many cases before signing a job contract. Nevertheless, this decline may have been also affected by the 2007 economic crisis since a lower number of employees is correlated with a lower risk of job accidents. The unluckiest months, with the highest accident rates in Italy, are March (1832 accidents), June (2015), July (2015), September (1934), and October (1890). These statistics also replicate major agricultural practices, including—but not limited to—the collection of rural products.



**Figure 1.** Accident trend in the primary sector in Italy over time (2012–2017).

The greatest amount of injuries occurred in central and northern Italy (Figure 2). There was a high number of accidents in central Italy, with a specific exposure of the female population (Figure 2a); however, in the other macro-regions, the highest number of people injured was male.

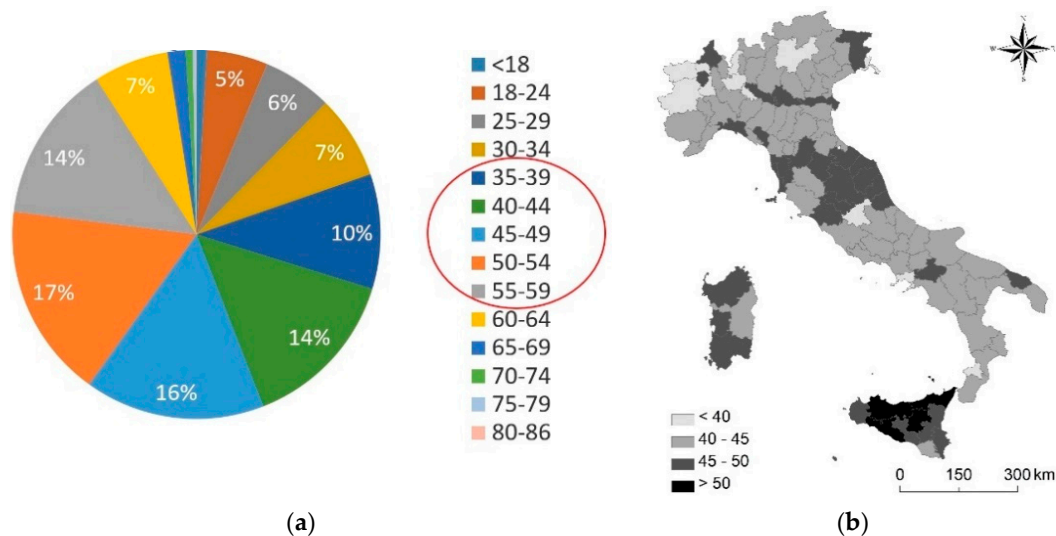
The administrative region with the largest amount of accidents is Marche, totalizing 4825 events overall (Figure 2b).



**Figure 2.** People (males in blue and females in orange) involved in accidents by geographical subdivision (a) and distribution of accidents occurred in Italy; (b) by year (from 2012 to 2017).

The age groups between 35 and 60 years assumed the highest number of accidents in the past 5 years: there were almost 15,000 injuries with people in this age cluster (about 71% of the sample). Moreover, the map in Figure 3b shows that the average age of the injured people was over 50 years old in Sicily (southern Italy); however, the age range between 45 and 50 years was the most representative class for accidents recorded in central Italy and in the districts along the Po river, as well as in Sardinia.

The proposed examination also acknowledged the foreign population involved in work-related injuries (Table 1). The Romanian population is the most affected one in the past 6 years: 533 people were involved in accidents at work. In any geographical distribution in Italy, Romanians are continuously the largest number of people injured, followed by Moroccans (309 events), Albanians (261) and Macedonians (121).



**Figure 3.** Age groups of people involved in accidents (a) and average age of the injured people at provincial level (b).

**Table 1.** Number of foreign population involved in work-related accidents by geographical subdivision.

Nationality	Central	Island	Northeastern	Nord-Western	Southern
Romania	137	11	215	111	59
Morocco	38	2	170	83	16
Albania	110	2	90	49	10
Macedonia	62	1	22	24	12
Swiss land	60	5	23	5	26
Tunisia	16	12	53	11	8
Germany	35	11	17	9	23
India	6	1	29	40	1
Moldavia	5	0	54	14	1
Senegal	11	0	26	19	3

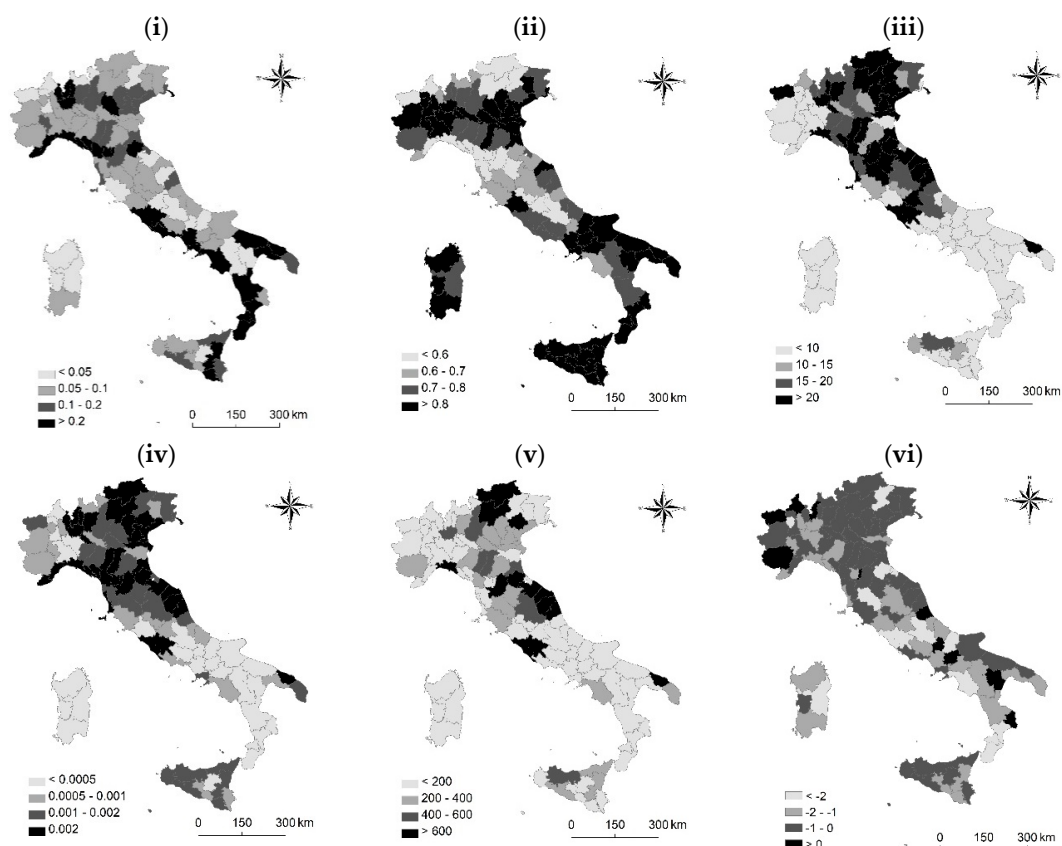
A comparison of these data with contextual information derived from the Italian agricultural census may shed more light on the spatio-temporal pattern of job accidents in agriculture (Figure 4). Six indicators were then calculated:

- number of people employed in agriculture on utilized agricultural area (UAA);
- ratio of utilized agricultural area (UAA) on the total agricultural area (TAA);
- number of accidents on the number of people employed in agriculture per 1000 employees;
- number of accidents in relation to utilized agricultural area (UAA);
- number of accidents normalized in relation to the utilized agricultural area (UAA) on the total agricultural area (TAA);
- percent change of the total number of accidents recorded in 2017 (the final year of investigation) and 2012 (the first year of investigation).

The areas that experience the strongest incidence of workers in the primary sector relative to Utilized Agricultural Area (UAA) are situated along coastal areas, flat lands and the main waterways (e.g., Po River), possibly indicating agricultural intensification. However, the inland mountainous regions have a lower rate for this indicator. Strongly used rural areas are the northern districts, especially along the Po river, some central provinces (e.g., Viterbo), the major islands and the Apulia region. As already mentioned, the highest amount of accidents at work to the total number of people employed in agriculture per 1000 employees was recorded in the north-central areas of Italy (e.g.,

Aosta, a large part of Veneto, Marche and Trentino); the only southern province which recorded a particularly high rate is Foggia, having a high value of UAA in TAA. The fourth indicator integrated the previous ones, indicating together (i) the most productive agricultural areas; and (ii) the most dangerous territorial contexts, which are associated with a high incidence of employees. The empirical findings of the present study showed also the riskiest provinces (Vicenza, Lucca and Roma) based on the amount of fatalities. The fifth indicator quantifies the number of accidents relative to the utilized agricultural area (UAA) and total agricultural area (TAA). In this instance, the most sensitive areas to job accidents are situated in central Italy, especially Marche region, which totalized the highest share of injuries.

The last indicator assesses percentage variation in the target variable between the final and initial year of investigation. Eleven provinces reported an increase in job-related accidents over time. A few of them are situated in north-western Italy (Cuneo, Aosta, Como, Monza and Brianza), while most of them are distributed in central-southern regions (Benevento, Teramo, Matera, Isernia, Prato, Crotona, Verbano-Cusio-Ossola). Conversely, the provinces that have experienced a halving of work-related injuries are situated in central and northern districts of Italy (e.g., Belluno, Forlì-Cesena, Siena, Rome). A few of them are situated in southern Italy (e.g., Salerno, L'Aquila, Campobasso, Reggio Calabria, Barletta-Andria-Trani). The large majority (90%) of Italian provinces witnessed a decrease over time in accidents at work in the primary sector.



**Figure 4.** Selected indicators illustrating (i) the number of people employed in agriculture on utilized agricultural area (UAA); (ii) the ratio of utilized agricultural area (UAA) in the total agricultural area (TAA); (iii) the number of accidents in the total number of people employed in agriculture (per 1000 employees); (iv) the number of accidents to the total UAA; (v) the number of accidents to the total UAA, normalized by TAA); and, finally, (vi) the per cent variation between accidents occurred in 2017 (final year of investigation) and 2012 (first year of investigation).

To assess whether recent job accidents take on the same trends, PCA results show the overall performance of each Italian province (Figure 5). According to components 1 and 2, Marche assumed a specific distribution in respect with the other areas, due to the high number of accidents recorded. Territorial areas that experienced the highest values as for the amount of accidents per 1000 employees and per UAA are shown in the right part of the graph. Three provinces (Forlì, Brindisi and Rome) offer a specific outline: accidents in these areas occur especially during autumn (e.g., October). This outcome is possibly connected to the dominant cropping system, based on vineyards and/or fruit crop. Component 3 highlighted the areas with a strong incidence of accidents in the first year of detection (2012), mainly corresponding to winter months. PC4 outlined the provinces with a particularly high accident rate in 2014, and a lower rate for 2016. The analysis also shows accidents occurred in February, consequently revealing a larger risk of agricultural practices correlated with soil preparation.

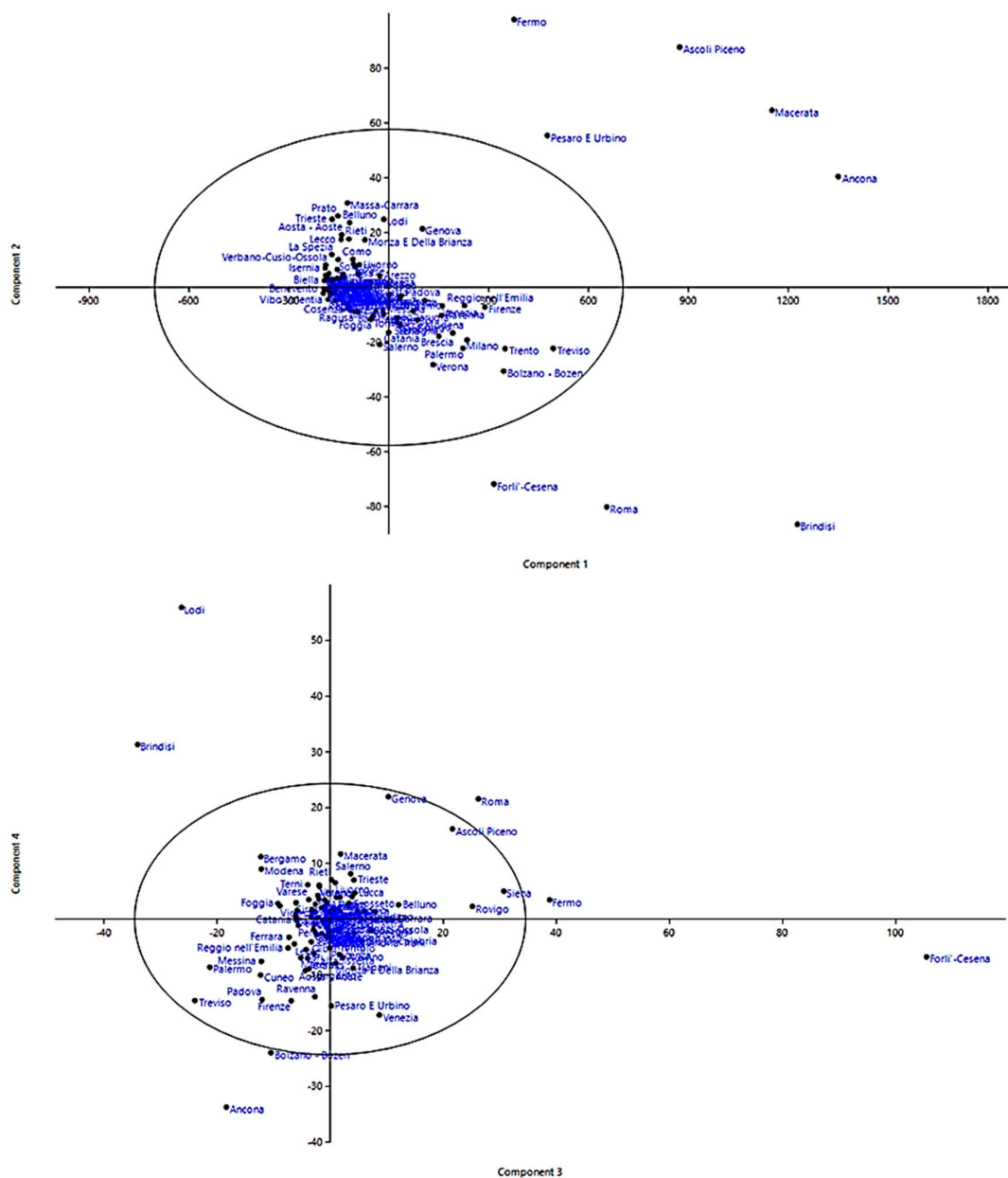


Figure 5. Score plot of principal components (upper panel: PC 1 vs. 2; lower panel: PC 3 vs. 4).

#### 4. Discussion

The chief objective was to identify the most relevant accident causes, intended as a knowledge base to define appropriate prevention measures [57,58]. In these respects, statistics were collected in a comparable form across countries and were updated in suitable datasets following classification systems and official registration measures [59,60]. However, standardized legal notification and registration systems are usually not so simple [57], or quite different across European countries [58,61]. The (changing) geography of accidents at work in the primary sector is a quite unexplored topic in the scientific literature [13]. In this regard, major attention is often given to other economic sectors deemed to be hazardous [4], e.g., construction activities [62–65].

As far as safe working in agriculture is concerned, the existing programs to reduce injuries are often grounded on a largely variable (and sometimes mixed) understanding of related risky activities [66]. Exploring job accidents in selected socio-demographic dimensions (e.g., place, gender, age, nationality of the person involved) bring about the opportunity to examine the intimate characteristics of the working environment [56]. Empirical findings revealed that the number of injuries has followed a declining trend over time, likely influenced by a thorough (often compulsory) supply of educational courses dealing with safety at work. For the primary sector, the most critical months are March, June, July, September and October, which likely reflect the most dangerous agricultural practices. Our results proved that the greatest number of injuries occurred in central and northern Italy, with a specific socio-demographic profile (males aged 35–60 years old). The influence of agricultural workplace accidents on older people can expose a requirement to oversee the role that increased age plays in relation to performance and attention in the workplace [52,66].

With continuous routine, risks may be more lightly perceived during certain custom practices, while being a potential for accident involvement. Therefore, risk perception is strongly linked to having attended training courses; nevertheless, those workers who attended courses do not always assume a safe performance [67,68]. An improved analysis of the tasks to be carried out and the quality of training is essential since information and training—at least in the primary sector—cannot be acquired mechanically, but constitute a real dynamic process [51].

Also, the foreign population was involved in work-related injuries, especially Romanian people. The analysis of statistical indicators makes it possible to evaluate exposure to risk of work accidents. However, it is also necessary to integrate this data with information on irregular jobs typical of certain areas [53]. For instance, in southern Italy, work is often irregular and without any legal contract: in the instance of a professional accident, the employee is not protected and cannot report the episode. Moreover, in Italy, as in other countries such as in France, statistics are also used to establish (business) contribution rates to ensure coverage of costs arising from accidents at work [59]. Therefore, the social safekeeping rate is variable, depending on accident costs. Such policies can be used to a greater extent as an economic incentive for the introduction of preventive measures [58,60]. Conversely, the financial pressure on employers could lead to an under-declaration of accidents [59].

By giving new job opportunities to the primary sector, which plays a fundamental role for the environment, landscape and food production [32,42–44,68–71], working safety protocol is unavoidable. While taking care of workers' safety [69], farming activities continue to play a great role in regional economic systems [72–76]. Environments characterizing a farmer's job should be explicitly described and assessed in a comprehensive way [77–79]. Each type of accident should be classified according to standard nomenclature. Unfortunately, such specification is missing (e.g., overturning of tractors, other machinery, chemicals, mobile machinery) from some periods in the databases. Such enlightening lack should be filled with inferential procedures to identify which agricultural practices cause the most accidents and to design more specific training courses. Even if the amount of accidents has decreased over time, the increase in the sum of educational courses on safety at work is particularly relevant in Italy. A decline in job fatalities may also have been affected by the economic crisis [38,43], since a low number of employees is correlates with a low risk of accidents.



Industrial policies and rural development strategies should also propose innovative solutions for the primary sector, since it is essential that operators' safety is guaranteed during the production process. Since the current incidence of injuries in the agricultural sector is still relevant in Italy, careful analysis of the most effective interventions should be addressed and implemented [52]. In this regard, accurate recommendations may combine practical, organizational and training actions [37,80–82]. In particular, in risky areas of the country, educational and training models should be implemented, defining a set of priorities, such as: (i) an interdisciplinary program providing more specialized courses, in addition to the plan foreseen by law; (ii) an analysis of training targets and profiles; (iii) a definition of degrees of knowledge and competences of the trainers; (iv) development of technical sectors run by sector experts; and (v) dissemination of the model through info-points promoting awareness to job accidents [53]. Only by adopting a dynamic and contextualized model can a pilot assessment give positive outcomes in a given territorial area [53]. Also, the knowledge and application of precision farming technologies can be useful to prevent potential risks in rural activities [41,83,84]. In fact, the fall in accidents is due to several factors which do not involve training. For instance, the decreasing rate may be due to greater automation and technologies in the agricultural sector. In addition, data processing is essential, such as the number of accidents that be normalized based on total hours worked by workers. However, in Italy, databases are not available; in the United States, industries are supervised by OSH (Occupational Safety and Health) and given as TRIR (Total Recordable Incident Rate) in accident units/100,000 h worked. The data analyzed in the present work refer to Italy, and our empirical findings may differ from those observed in other countries [62], but they may give insights into relevant common variables. Incidents that are not reported are excluded from the analysis. In future research, integrated indicators should be constructed with the aim of obtaining a more accurate approach to their influence on work accidents. For instance, climate variables may designate whether there are variances in the severity of accidents across Mediterranean areas and/or continental regions. Different training strategies need to be improved by advancing effectiveness of the agricultural workers' training.

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