Work-related road accidents: an in-depth statistical analysis carried out by two different integrated data sources

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Abstract

The aim of the paper is to provide an integrated overview on data included in Road accidents Istat (Italian National Institute of Statistics) register and Inail (Italian National Institute for Insurance against Accidents at Work) archive of work-related road accidents. The data sources available for the surveillance of road accidents have relevant limits, when taken separately. Data integration, performed by record linkage techniques, focusses on the enrich information associated to each road accident. Mainly, information on the circumstances of accident and characteristic of roads and vehicles are linked to information on professional condition, economic sector, type of injury and severity at individual level. Therefore, the integration of data is essential in order to build up a detailed picture to drive preventive actions.

Keywords: Road accidents, work-related road accidents, record linkage, compensation data.

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1. Introduction

Road traffic injuries are considered to have a relevant impact on public health. A relevant portion of these road accidents are of occupational origin. Istat (Italian National Institute of Statistics) and Inail (Italian National Institute for Insurance against Accidents at Work) produce the official statistical information on road accidents and work-related road accidents respectively.

Istat is responsible for processing and disseminating the official statistical information on road accidents in Italy. The domain of the survey, carried out by Istat, consists of all road accidents, occurred on the national public roads, resulting in death or injury (deaths within 30 days), detected by the Police and *Carabinieri* authorities.

Inail, based on its own official administrative archives, builds and provides statistical databases and institutional open data on accidents at work. Although these two archives present a reliable picture of both general and work-related road accidents, a complete information is missing. While the Istat archive of general road accidents describes the localisation, road characteristics, vehicles, accident type and weather conditions, the Inail one provides information related to occupational parameters such as the economic sectors, injuries and the length of leave. This means that information about the type of involved vehicle or the type of accident are missing in this archive. The connection between these two types of information would allow further and more detailed analysis of road accidents' cases.

An early pilot study about general and work-related road accidents based on record linkage application was carried out by Istat and Inail using accidents occurred during year 2015 (Brusco *et al.*, 2019). The limited amount of data did not allow having a full description of the subject as well as its time variability.

So far, Istat and Inail disseminated several studies concerning the use of record linkage techniques to add valuable information to the road accident source based on Police records. The main field explored by Istat was the association between the Road Accidents survey and the Causes of Death register at individual level. The aim was to provide a set of integrated information for each dead person in a road accident, such as data on cause and cause of death, the role of the deceased and the dynamic and circumstances of

the road accident. In addition, the results highlighted the context factors for the road accident, mainly the social and safety ones, and contributed to the updating of systems of indicators on public health and security (Tuoto *et al.*, 2018 and 2012).

In order to provide a more complete description of work-related road accidents not available in the traditional dissemination of results and enriched in its contents, a record linkage between Istat road accidents data and Inail information on work-related road accidents was performed. The integration of information, mainly, focusses on joining the characteristics of road accidents, dead or injured drivers, passengers or pedestrians and vehicles with data on the professional condition (work/work commuting), economic sector, type of injury and severity at individual level (Taiano *et al.*, 2021)3. The analysis of the record linkage between data sources, in the field of work-related road accidents is included in the Italian National Statistical Programme and authorised by the Data Protection Authority.

3 The classical approach to the record linkage theory is due to Fellegi and Sunter (1969). The *RELAIS* toolkit developed by Istat and used to perform the linkage, applies the Fellegi and Sunter method; the methodological aspects are explained in the article by Taiano, L. *et al.*, "Work-related road accidents: a data linkage procedure applied to assess traffic accidents at work and commuting". In this issue of the *Rivista di statistica ufficiale*, N. 3/2021.

2. Materials and methods

2.1 Integrated databases of work-related road accidents

The present study is based on an integrated work-related road accidents archive obtained from a data linkage procedure better described in an accompanying paper (Taiano *et al.*, 2021), covering events occurring during year 2014-2018. Briefly, starting from the general and work-related road accidents archives, a multiple steps data linkage procedure was applied using deterministic and probabilistic approaches.

Although the full years dataset represents a rich source of information useful to define the time trend of the integrated variables, the study presented in this article concerns a detailed descriptive and in-depth analysis of variables focussed on the year of data 2018 only.

This choice is due to different reasons. First, the data of year 2018 was the last available one, providing updated information, as well as more robustness and completeness, which gradually improved over the time.

The second reason is due to similarity among the distributions across the years, similar in the shape, for the main variables studied, during the five-year period considered. The analysis is mainly based on the percentage frequencies of the linked cases and the most representative variables of the integrated dataset, for each year in the period 2014-2018. A Chi Square (c2) test was applied. The Pearson Test Chi Square (c2), in fact, is the well-known method used to verify the association between the variable "year of event" and the other main variables of the study too. The method states when the observed distribution of data fits with the distribution expected whether the variables are independent or not (See Figure 3.1-3.3, Table 3.1 and Appendix - Table A4).

The application of record linkage techniques between the two databases was particularly useful for enhancing the potential of different types of data and filling some information gaps too. In addition to the statistical examination of the integrated data, picking up the benefit brought by the two sources, a new reading key of the themes was applied too. Finally, the authors introduced a rich appendix supplement.

2.2 Data sources: strengths and limits

The analysis of the integrated information requires a special attention for the results evaluation, in consideration of the differences in definitions and domains between the two examined universes.

The Istat "road accidents survey" collects all road accidents resulting in death (within the 30th day) or injuriy, involving at least a vehicle circulating on the national road net and registered by a Police authority (Convention of Vienna, 1968 and United Nations, 1977; European Union, United Nations, OECD, ITF and Eurostat,, 2019; European Commission, 2021). The survey carried out by Istat, with the cooperation of ACI (Automobile Club of Italy) and other public national institutions, is an exhaustive data collection (included in the National Statistical Programme). The data collection system has been adapted to the local level organisation and needs. Istat adopted a flexible data flow model, through the subscription of special agreements with Regions (NUTS2 level) and Provinces (NUTS3 level) (Eurostat Nomenclature of Territorial Units for Statistics, 2021), to facilitate the local authorities' information needs and to improve the timeliness and quality of data collected.

The new geography of the organisation models, in fact, allowed over the time to have a gradual improving of the coverage of the number of accidents and of the completeness of all information, included the date, the coordinates and the demographic information of individuals, useful to optimise the linkage procedures.

The accidents at work, included the claimed road accidents at work, registered by Inail, consists of all cases occurred during the course of work for violent and external causes that determined temporary (> 3 days) or permanent disability or death (Article 2 DPR n. 1124/1965). Accidents "in commuting", *i.e.* road accidents that occur during the journey between home and the workplace and vice versa are included too (Article 12 DL n. 38/2000). From 12 October 2017, accidents reports include communications made only for statistical and information purposes, with the consequent absence from work of at least 1 day too (Article 18 DL n. 81/2008). Such cases, for the previous years, were included in the deductibles of injury below the 3-day threshold. The reported fatal events, on the other hand, consider all cases for which the death is a consequence of the accident.

The number of injured or deceased successfully linked, from the two Inail and Istat databases, is about 26,000 every year, during the period 2014-2018 examined. This amount represents respectively the 28%, out of the total insurance claims of workers for road accidents during work or work commuting (*in itinere*), and the 10% out of the total number of persons, with injuries or dead, involved in road accidents, detected by Police.

Concerning the percentage of linkage between the sources and the evaluation of the goodness of the integration procedure, it is to notice that the difference in domains dimension of the two data sources implies that not all the accidents, with consequent insurance claims of workers, are included in the general road accidents collection denounced by Police and registered by Istat. The last characteristic is in fact the condition of belonging to the Istat domain. Istat does not count all general road accidents if self-declared by the users to the vehicle's insurance companies without the intervention of a Police authority, even when an injured person is involved.

In addition to that, not all work-related road accidents produce a request of compensation to Inail. These missed registrations occur particularly for commuting road accidents and the amount cannot be counted. Consequently, as for the total amount of the road accidents, we could have an underreport of work-related cases.

In summary, only a portion (28%) of the registered work-related road accidents can be found in the complete road accidents archive, and it represents a portion (injured or fatal events) of the whole domain of road accidents occurred in the country (including accidents with only damages to vehicles and without injured persons). According to the dimension of linked cases (about 26,000 every year in the period considered), we are confident about their ability to describe the studied topics.

3. Statistical analyses of the integrated database of work-related road accidents

3.1 General and work-related road accidents: an overview

As previously stated, the analysis focusses on 2018, the last available for the integrated data. Before introducing the results of the data linkage, and providing a complete picture of the framework, some general information is useful about the total number of the general road accidents and of claims for road accidents at work occurred in 2018.

In 2018, 172,553 road accidents occurred in Italy resulting in death or injury (Istat and Police source), down comparing with 2017 (-1.4%), with 3,334 deaths (within 30 days) and 242,919 injured (-1.6%). The number of deaths decreases to 2017 (-44 units, -1.3%), after the increase detected in the previous year. Among the victims, the number of pedestrians (612, +2%), moped users (from 92 victims up to 108) and trucks occupants (189, +16%) increased. The motorcyclists (687, -6.5%), cyclists (219, - 13.8%) and passenger cars users (1,423, - 2.8%) showed a decrease. Although, the total amount of deaths decreased, the number of casualties on motorways (including ring roads and motorways junctions) increased – from 296 in 2017 to 330 in 2018; +11.5% – due to the accident occurred in Genova on August 14 on the Morandi bridge of the A10 Genova-Savona-Ventimiglia, which involved many vehicles and caused 43 casualties. On rural and built-up-area roads, a decrease of victims was recorded (1,603 deaths; -0.7% and 1,401 deaths; -4.5%). Distraction, failure in observing precedence rules and high speed (40.7% in total) were among the most frequent misbehaviour. The most sanctioned violations of the Road Traffic Act were, indeed, failure to comply with the signs; failures to use safety devices and the use of mobile phone driving as well as high speed (Istat 2019).

Injuries reported to Inail and occurring in 2018, updated to 30 April 2020 (the last date available before the linkage), were just over 645 thousand, slightly down (- 0.2%) compared to 2017. There were 1,264 fatal events reported in 2018, up of 8.9% on 2017. While 14.7% of overall accidents were road accidents, the percentage of fatal accidents was 46.5%.

About 420,000 work-related accidents were positively defined and about 15% were road accidents. Among the 1,264 fatal cases, 60.9% are positively defined and almost 58.2% are fatal events occurring on the road.

The data confirms the high danger potential of the "road risk", the incidence of fatal cases for the accidents at work, out of the total is indeed much higher for road accidents than in non-road accidents, with more serious consequences for the injured too.

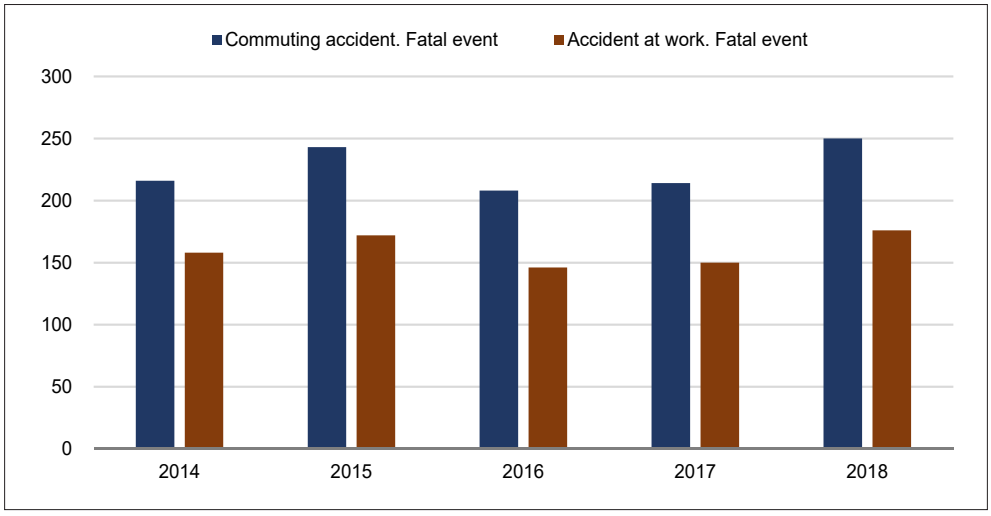
3.2 Work-related road accidents: focus on 2018 integrated data

3.2.1 Description of work-related road accidents by collision variables

The work-related road accidents integrated database was built for five years 2014-2018, where the variable "Year" represents the year in which the accident occurred.

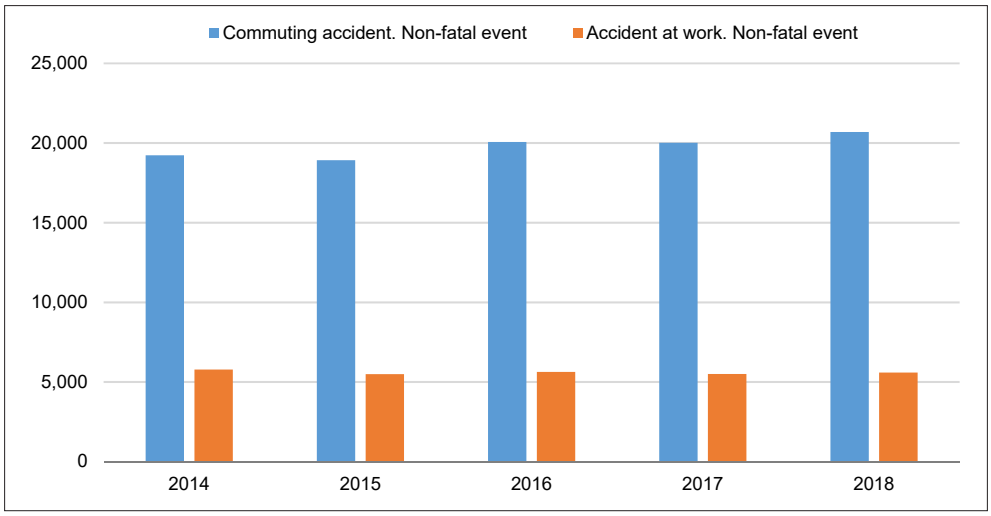
The first figures and tables describe the trend of the whole series, but in the following descriptive analysis, only the last available year, 2018, is considered. (Figures 3.1-3.3, Table 3.1 and Appendix - Table A4).

Figure 3.1 - Fatal injury claims due to road accident by type. Years 2014-2018 (absolute value)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Figure 3.2 - Non-fatal injury claims due to road accident type. Years 2014-2018 (absolute value)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Trend in the years

The work-related road accidents linked are 26,711 in 2018. This value is stable over the years considered, 2014-2018 with a slight decline in 2015. In 2018, 426 road accidents related to work were fatal and 26,285 were non-fatal (Figure 3.1, Figure 3.2 and Appendix - Table A4).

In the five years considered, 2014-2018, the percentage of non-fatal work-related road accidents has been unvaried, about 98.5%, versus 1.5% for fatal work-related road accidents (Table 3.1).

Table 3.1 - Injury claims due to road accident by event. Years 2014-2018 (absolute value)

Years	Fatal event	Non-fatal event	Total
2014	374	25,009	25,383
2015	415	24,409	24,824
2016	354	25,693	26,047
2017	364	25,508	25,872
2018	426	26,285	26,711

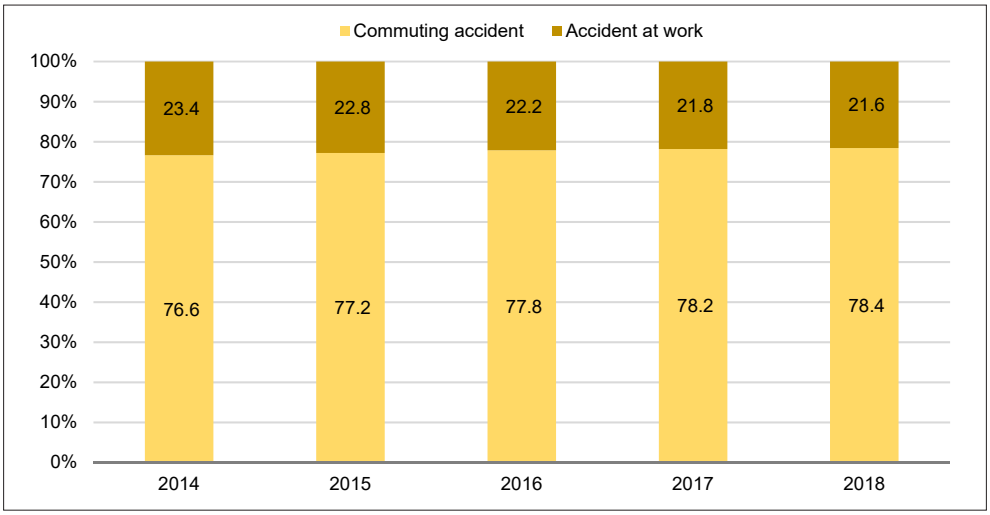
Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Work-related road accidents are divided into two large groups: commuting accidents and accidents at work (Appendix - Table A1).

In 2018, road accidents at work amounted to 5,767 and commuting accident to 20,944.

The injury claims due to road accidents are mostly commuting accidents: they were 78.4% in 2018. Just 21.6% were accidents occurred at work. These values are constant in the recent years: one in five injury claims involves a professional driver (Figure 3.3).

Figure 3.3 - Injury claims due to road accident by type. Years 2014-2018 (percentage value)

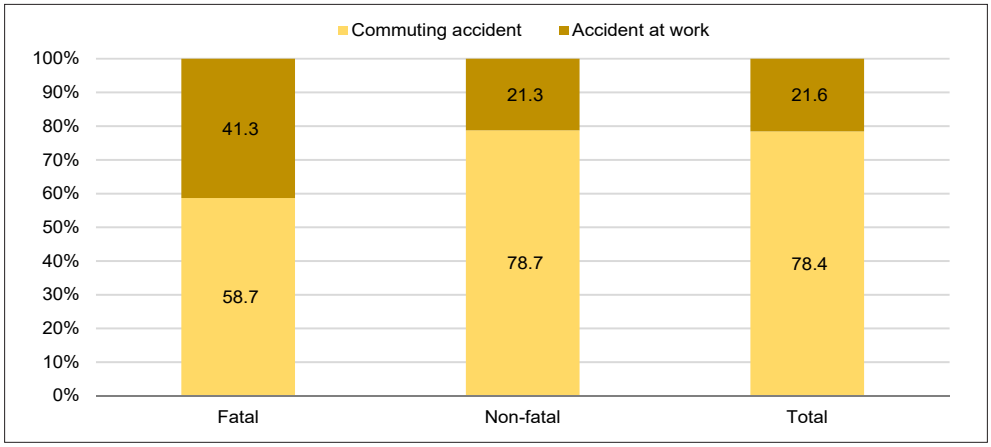


Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Fatal and non-fatal accidents

The 41.3% of fatal accidents occurs at work, so they involve professional drivers (Figure 3.4). Among non-fatal accidents, the percentage of professional drivers is 21.3%. With respect to the total number of accidents, those occurred during work are fatal in 3.1% of the cases, while the percentage of fatal accidents drops to 1.2% if we consider the commuting accidents.

Figure 3.4 - Injury claims due to road accident by event. Year 2018 (percentage values)

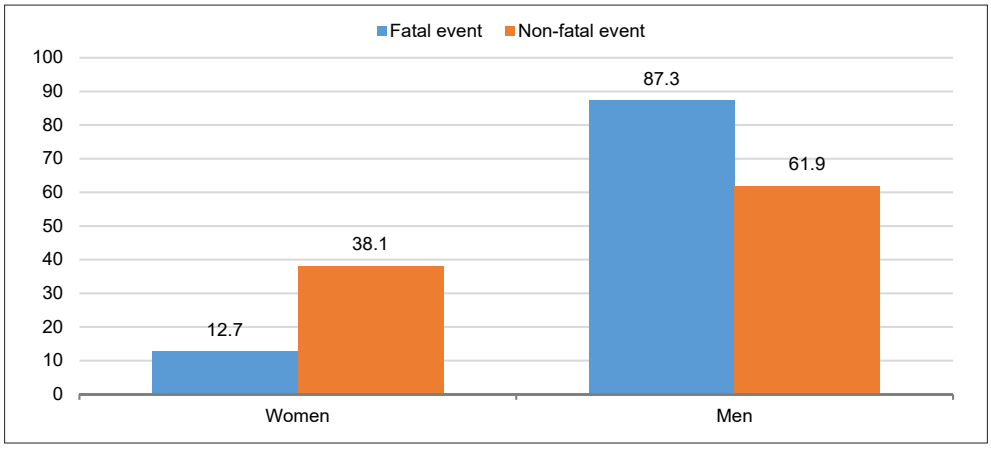


Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Women and men

Injury claims mainly involve men. Work-related road accidents involve in out of 10 cases 6 men (62.3%). This percentage is stable if we consider non-fatal events alone (61.9%) (Figure 3.5). This percentage rises to 87.3% if we consider fatal work-related road accidents, maybe because they are men professional drivers. Non-fatal-work-related road accidents are 38.1% in women.

Figure 3.5 - Injury claims due to road accident by event and gender. Year 2018 (percentage values)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Age

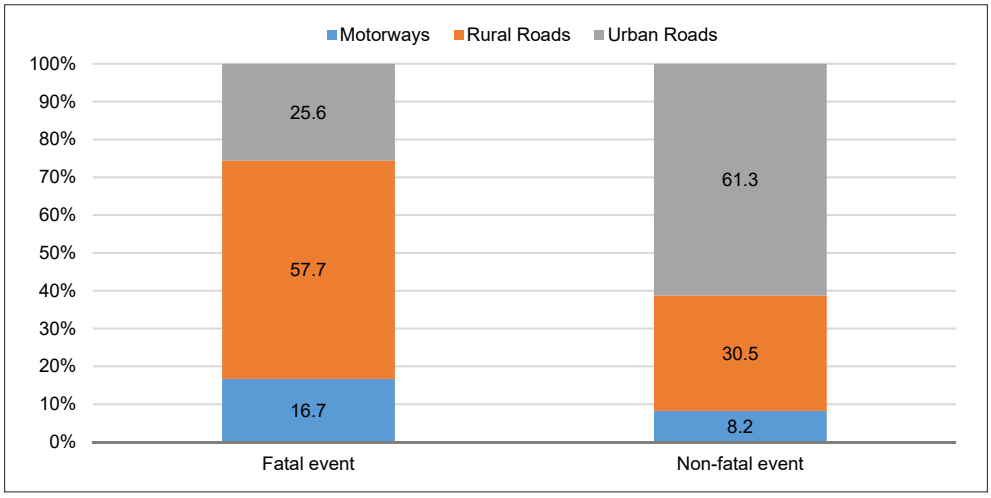
In 2018, 70% of injury claims due to road accident involve people aged 49 and over. This value is the same in non-fatal events. There is a change among the fatal events: 7 out of 10 incidentals occur among people who are 35-64 years old. (Appendix - Table A2).

Road type

Injury claims due to road accident mostly occur on urban roads, about 6 out of 10 cases. In 2018, 16,214 (60.7%) work-related accidents happened on urban roads and 8,270 (31.0%) occurred on rural roads. Considering fatal accidents, the percentage of those happening on rural roads rises to 57.7% (Figure 3.6).

Focussing on the outcome of the accident, non-fatal accidents have the same percentages as overall accidents: 60.7% overall accidents occur on the urban roads, 31.0% on the rural roads and 8.3% on the motorways. There is a difference in fatal accidents. The percentages of accidents on the motorways and on rural roads double considering fatal accidents: 16.7% on motorways and 57.7% on rural roads.

Figure 3.6 - Injury claims due to road accident by localisation of the accident and event. Year 2018 (percentage values)



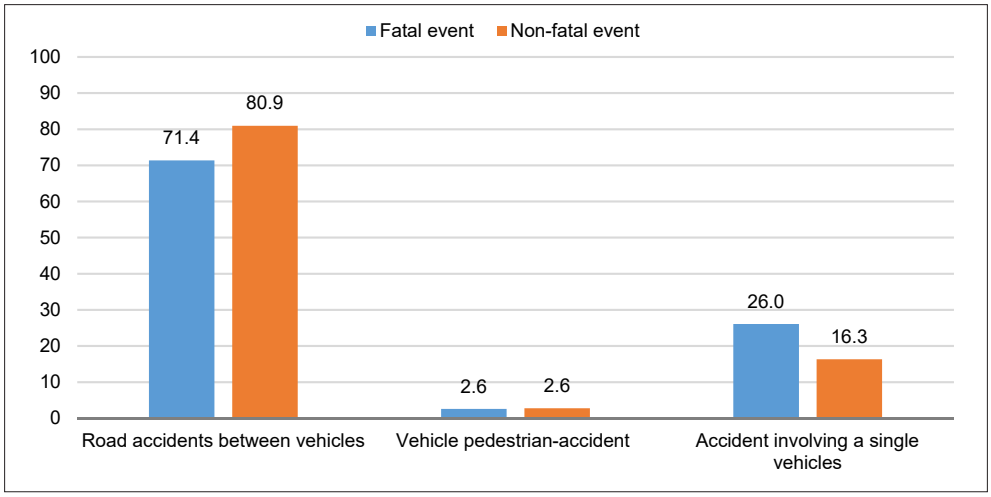
Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Accident type

Work-related road accidents involve at least two vehicles in 80.8% of cases. A very similar value is also found among non-fatal accidents: 80.9% (Figure 3.7).

The percentage of accident involving a single vehicle is 16.5% but among fatal accidents this value is 26.0%.

Figure 3.7 - Injury claims due to road accident by event and road accident group type. Year 2018 (percentage values)

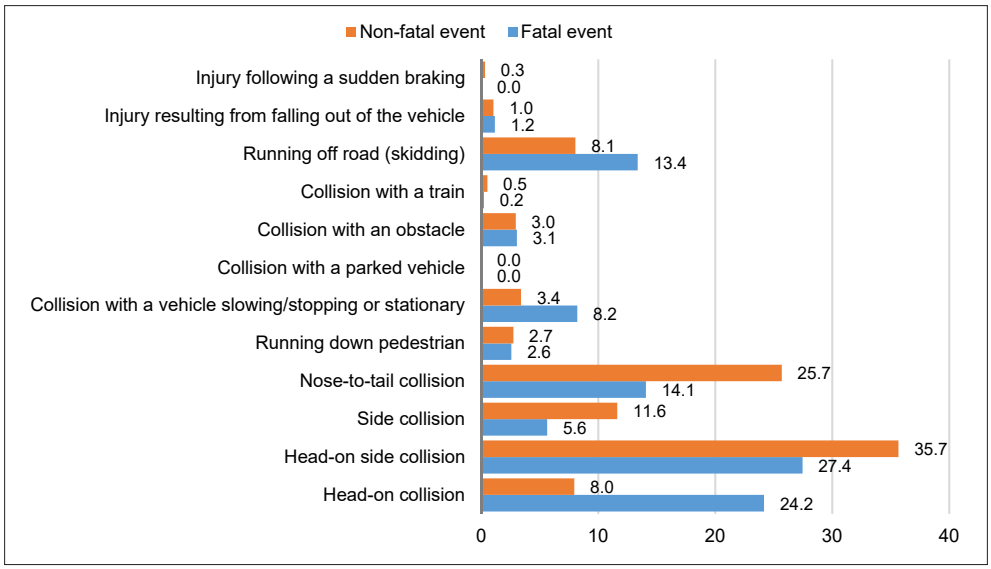


Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

About the road accident type, it is possible to see in detail the various types of accident.

The most common accident type between non-fatal accidents is head-on side collision (35.7%) and nose-to-tail collision (25.7%) (Figure 3.8). Among the fatal accidents the most frequent types are, again, head-on side collision (27.4%) and head-on collision (24.2%). The percentage of fatal accidents due to head-on collision is three times the non-fatal ones. The peculiarity of fatal accidents is that it presents higher percentages than non-fatal accidents for two other types of accident: running off road (skidding) (13.4%) and collision with a vehicle slowing/stopping or stationary (8.2%).

Figure 3.8 - Injury claims due to road accident by event and road accident type. Year 2018 (percentage values)



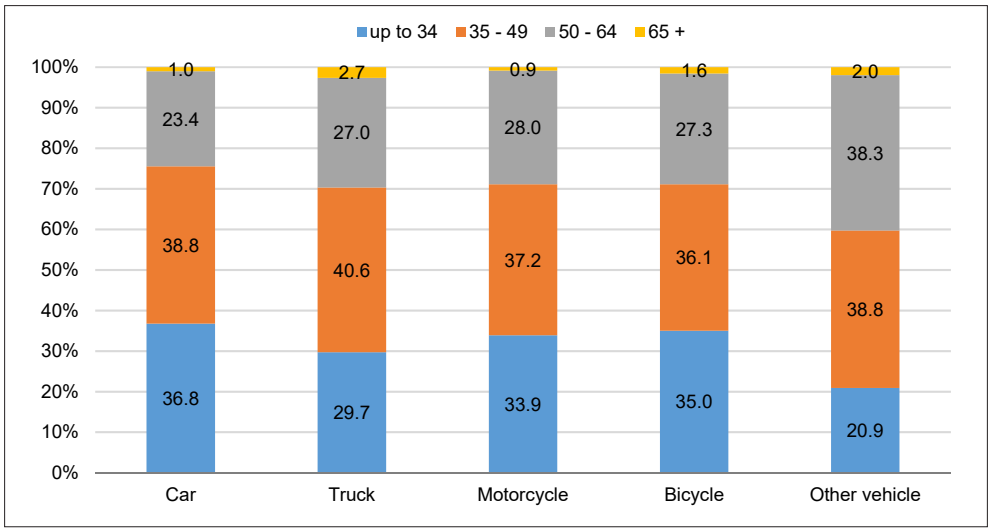
Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Vehicle type

More than half (57%) of injury claims due to road accident occurs to car passengers and 25% to motorcycle passengers (Appendix - Table A3).

People travelling in a car, as a driver or passenger, involved in an injury claims due to a road accident are young with an age of up to 34 years in 36.8% of cases (Figure 3.9). Truck drivers are adults aged between 35 and 49 in 40.6% of cases, like those who travelled on motorcycles (37.2%).

Figure 3.9 - Injury claims due to road accident by age class of users and vehicle type. Year 2018 (percentage values)



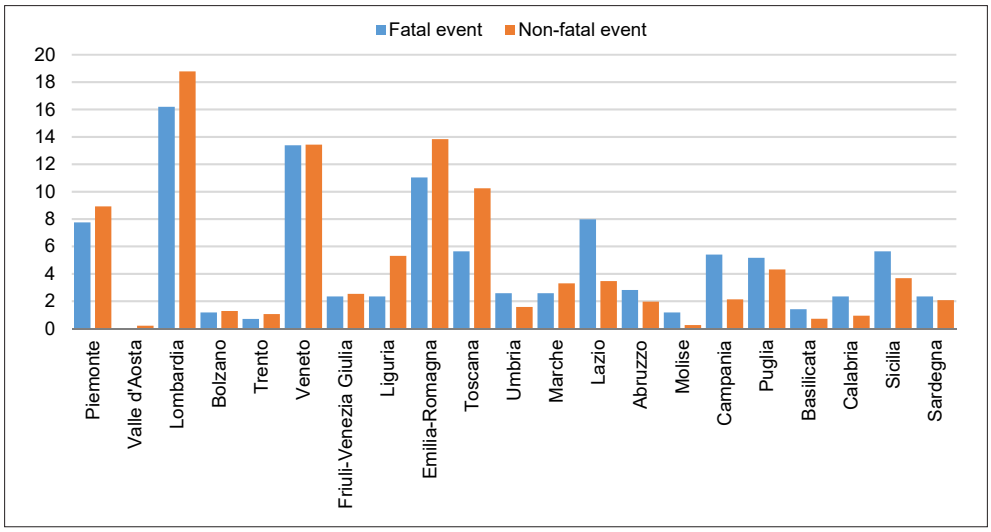
Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Territorial Area

Half of the accidents occur in four Italian regions: Lombardia (18.7%), Veneto (13.4%), Emilia Romagna (13.7%), and Toscana (10.2%) (Figure 3.10).

In the Central and Southern regions, the percentages of fatal accidents are higher than non-fatal ones, with the exception of Toscana and Marche.

Figure 3.10 - Injury claims due to road accident by event type and region. Year 2018 (percentage values)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

It is interesting to analyse the situation of work-related road accidents in large geographical areas with respect to the type of traffic signs and the type of road pavement.

In the South and the Islands, the accident rates occurring on roads with absent traffic signs are higher than in the North and Centre. 13.7% in the South and 12.8% in the Islands of accidents occur on unmarked roads compared to 4.3% in the Nord-West, 3.8% in the Nord-East and 6.3% in the Centre (Table 3.2). The presence of double signs, both vertical and horizontal, is lacking in the South and the Islands where only 58.4% of accidents occur on roads with double signs. In the North, the values are higher.

Table 3.2 - Injury claims due to road accident by traffic signs and geographical distribution. Year 2018 (percentage values)

Traffic signs	North-West	North-East	Centre	South	Islands	Italy
Absent	4.3	3.8	6.3	13.7	12.8	6.0
Vertical	4.3	5.5	8.0	18.1	15.7	7.5
Horizontal	8.2	8.7	8.0	8.9	12.0	8.6
Vertical and horizontal	82.6	81.6	76.9	58.4	58.5	77.3
Temporary construction site	0.6	0.4	0.8	0.9	1.0	0.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Almost all of the road work-related accidents in Italy occur on paved roads (Table 3.3). It is interesting to see the values, even if low, of the accidents that occur on bumpy paved roads or unpaved roads. In the South, the percentage is higher on bumpy paved roads (0.9%) and in the Centre on unpaved roads (0.4%).

Table 3.3 - Injury claims due to road accident by pavement and geographical distribution. Year 2018 (percentage values)

Paving	North-West	North-East	Centre	South	Islands	Italy
Paved road	99.6	99.6	99.0	99.1	98.9	99.4
Bumpy paved road	0.3	0.3	0.6	0.9	0.8	0.4
Unpaved road	0.1	0.1	0.4	0.0	0.3	0.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

3.2.2 Association between road accidents, place and vehicles type, economic categories for compensation and site of injuries

Analysis by vehicle type

An analysis of accidents by type of vehicle involved shows that the majority of fatal events occurred with trucks (3.3%) while all vehicles account in average around 98% in non-fatal events.

In 2018 the accidents involving a private car[4] unfortunately account for the highest number of fatal (over 40%) and non-fatal (around 55%) accidents, followed by those involving a motorbike (around 30% for fatal and just over 24% for non-fatal accidents) (Figure 3.10).

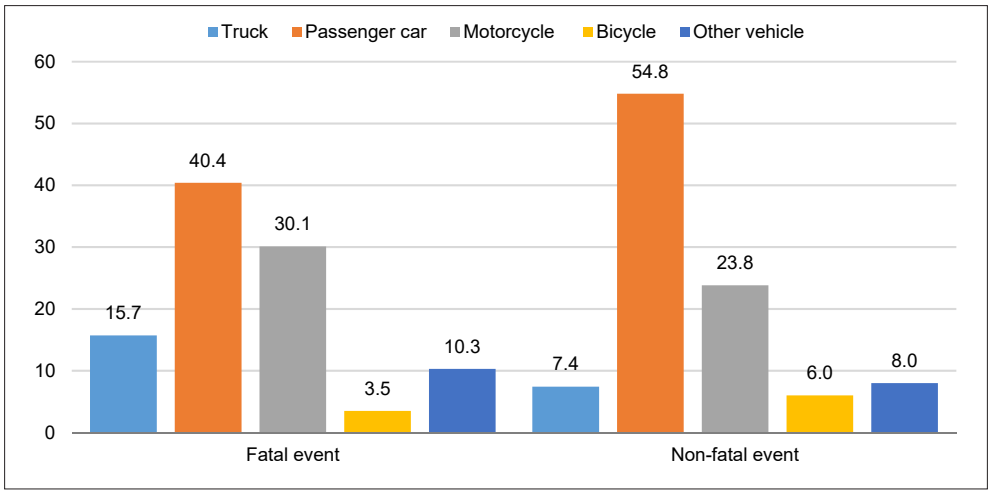
Table 3.4 - Percentage of Injury claims due to road accident by vehicle type and event outcome. Year 2018

Event	Car	Truck	Motorcycle	Bicycle	Other vehicle	Total
Fatal event	40.4	15.7	30.1	3.5	10.3	100.0
Non-fatal event	54.8	7.4	23.8	6.0	8.0	100.0
Total	**54.5**	**7.6**	**23.9**	**5.9**	**8.1**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

4 Inail only compensates a commuting accident by private vehicle if the use of the vehicle is necessary, *e.g.* because it is impossible to reach the place of work or it is too far and too long to travel by public transport compared to private transport.

Figure 3.11 - Injury claims due to road accident by event outcome and vehicle type. Year 2018 (percentage values)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Analysis by consequences

In the event of an accident at work or occupational disease, Inail provides the worker with the welfare benefits established by law. These benefits are differentiated according to the consequences of the accident in temporary disability, permanent disability or death. In case of absolute temporary inability to work, an indemnity is paid in lieu of salary until clinical recovery; if the accident results in permanent biological damage between 6% and 15% of the psychophysical validity, a capital indemnity is paid for the psychophysical impairment suffered by the worker. If the accident results in permanent biological damage of less than 6%, no compensation will be paid by Inail (so-called excess). If the degree of ascertained impairment of psychophysical integrity is between 16% and 100%, the worker is paid an annuity. Finally, if the worker dies because of an accident at work, an annuity is paid to the survivors. Table 3.5 shows the percentage of compensated injuries by vehicle involved and type of compensation.

Table 3.5 - Compensated injuries due to road accident by vehicle type and type of compensation. Year 2018 (percentage values)

Type of compensation	Car	Truck	Motorcycle	Bicycle	Other vehicle	Total
Lump sum	31.1	6.0	43.8	8.9	10.2	100.0
Survivor's pension	39.3	15.6	26.8	4.0	14.3	100.0
Direct pension	32.9	7.3	43.0	4.2	12.6	100.0
Temporary	58.6	8.9	19.2	5.5	7.8	100.0
None	56.0	5.5	25.1	6.1	7.3	100.0
Total	**54.5**	**7.6**	**23.9**	**5.9**	**8.1**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Two out of three of all road accidents are positively recognised and compensated. The number of men (workers) who receive compensation is higher than the number of women (workers) (64% against 36%) regardless of the type of vehicle involved, while women (workers) receive more compensation than their men colleagues when the vehicle involved is a private car (50.5% compared with 49.5%).

Private cars and motorbikes are the means of transport with the highest number of fatal road traffic accidents and consequently the highest number of survivors' pensions (39.3% and 26.8% respectively).

In 43% of motorbike accidents, a permanent disability and hence a direct pension is awarded, even if the disability does not exceed 20%. Some 33% of direct annuities were paid out to workers who were injured while driving a private car.

About 59% of temporary compensations are provided to private car drivers involved in road accidents.

Table 3.6 - Injury claims due to road accident by nature of injury and vehicle type. Year 2018 (percentage values)

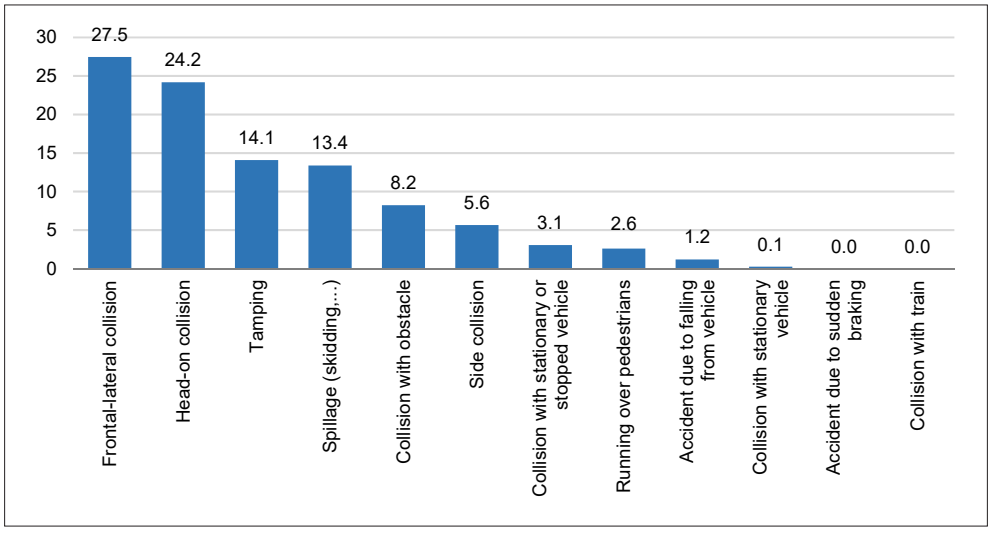
Nature of injury	Car	Truck	Motorcycle	Bicycle	Other vehicle	Total
Bruise	24.7	29.8	41.8	56.3	38.2	32.0
Foreign bodies	-	0.1	-	-	0.1	-
Wound	2.2	3.7	5.4	4.3	4.0	3.3
Fracture	13.0	17.7	39.1	27.1	26.7	21.3
Injuries from other agents	0.3	0.6	0.2	0.2	0.5	0.3
Stress injuries	-	-	-	-	-	-
Dislocation, sprain, distraction	59.8	48.0	13.3	12.1	30.3	43.0
Anatomic loss	-	0.1	0.2	-	0.2	0.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

A cross-section of the data by type of vehicle involved and the nature of the injury[5] resulting from the accident shows that the majority of accident events give rise to injuries of the contusion, fracture and dislocation-distortion type. Results are shown in Table 3.6. Motorbikes and velocipedes were the main cause of contusions and fractures (41.8% and 56.3% for the former and 39.1% and 27.1% for the latter), mostly involving the upper and lower limbs, chest, internal organs and in some cases the head. Accidents involving lorries and private cars mainly involved dislocations and sprains (48% and 59.8% respectively), with 3 out of 4 cases involving the spinal column and a smaller percentage involving the head.

Looking at the "nature of the accident" and the damage resulting from it (Figure 3.12), it emerges that the most dangerous accidents, which account for 87% of all fatal accidents, are mainly due to: running off road (skidding) (13.4%), head-on collision (24.2%), frontal-lateral collision (27.5%), rear-end collision (14.1%) and collision with an obstacle (8.2%).

Figure 3.12 - Injury claims due to road accident by event outcome and vehicle type. Year 2018 (percentage values)



Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

5 Generic term for any change, in a pathological sense, in the structure and function of a tissue or organ, irrespective of the causes that may have produced it (*e.g.* mechanical, thermal, chemical, bacterial, *etc.*).

In Table 3.7 five types of accident are analysed in relation to the physical injuries sustained. As shown, injuries to the skull (58.5%) have the highest incidence for the cause of death, followed by injuries to the heart and mediastinal organs (16.1%), the 'chest wall' (10.7%) and those to the abdominal wall and organs (9.2%).

Injuries to the skull occur most frequently in accidents involving head-on side collision (71.0%), running off road (skidding) (63.9) and collision with an obstacle (61.1%), which are clearly due to the presence of older vehicles without side safety systems. The lowest value is found in head-on collision (40.0%), where frontal airbags are also present in older vehicles. Damage to the heart and organs of the mediastinum occurred most frequently in the head-on collision (28.3%) and in the rear-end collision (17.1%), which is clearly due to the vehicle coming to a violent stop. Damage to the abdominal wall and organs and to the thoracic wall generally occurs in almost all types of accident with values ranging from 5.6 per cent to 17.1 per cent.

Table 3.7 - Injury claims due to road accident by site of injury and type of accident. Year 2018 (percentage values)

Injury site	Running off road (skidding)	Head-on collision	Head-on side collision	Rear-end collision	Collision with obstacle	Other	Total
Neck	2.8	10.0	1.4	2.4	11.1	2.8	4.6
Skull	63.9	40.0	71.0	51.2	61.1	66.7	58.5
Heart and mediastinal organs	13.9	28.3	7.2	17.1	11.1	16.7	16.2
Abdominal wall and organs	8.3	11.7	10.1	9.8	11.1	2.8	9.2
Thoracic wall	11.1	8.3	10.1	17.1	5.6	11.0	10.7
Other location	-	1.7	-	2.4	-	-	0.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

By location of injury and driver/passenger role (Table 3.8), the passenger seat is more dangerous than the driver seat, demonstrated by the fact that for almost all injury locations, there are higher values for the passenger than for the driver.

Table 3.8 - Injury claims due to road accident by site of injury and role. Year 2018 (percentage values)

Injury site	Role			
	Driver	Passenger	Pedestrian	Total
Neck	4.3	5.9	9.1	4.6
Skull	57.7	58.8	72.7	58.4
Heart and mediastinal organs	16.4	17.6	9.1	16.2
Abdominal wall and organs	9.1	11.8	9.1	9.2
Thoracic wall	12.1	-	-	10.8
Other location	0.4	5.9	-	0.8
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work related road accidents' archive

Analysis by economical activity

Interesting analyses can be carried out by breaking down the accident cases by work activity, in particular by large tariff group[6].

The territorial distribution of accidents occurring at work in the Industry and Services sector (Table 3.9) shows that 60% of accidents in Miscellaneous (mainly services) occurred in the North, 60% in Construction in the North and 21.3% in the Centre, 34.5% in Agricultural work in the Centre-South and 63.6% in Transport in the North.

Table 3.9 - Injury claims due to road accident occurred at work in Industry and Services by large tariff group and geographical distribution. Year 2018 (percentage values)

Large tariff group	Centre	Islands	North-East	North-West	South	Total
Agricultural processing	28.0	8.5	22.0	24.6	16.9	100.0
Chemistry	20.0	5.0	27.5	40.0	7.5	100.0
Construction	21.3	6.3	26.7	33.1	12.6	100.0
Electricity	25.5	11.8	23.5	21.6	17.6	100.0
Wood and related	29.5	6.8	29.6	22.7	11.4	100.0
Metallurgy	18.9	3.7	34.7	32.3	10.4	100.0
Mining	29.4	5.9	41.2	23.5	0.0	100.0
Textiles and clothing	22.4	1.7	25.9	31.0	19.0	100.0
Transport	18.0	5.2	30.1	33.6	13.1	100.0
Miscellaneous	18.9	7.9	29.0	30.6	13.6	100.0
Total	**19.3**	**6.5**	**29.6**	**31.5**	**13.1**	**100.0**

Source: Authors' processing on integrated Istat and Inail work related road accidents' archive

6 The large tariff grouping that groups the tariff items, which associate the work with the premium rate.

The distribution of accidents by hour (Table 3.10) shows that most accidents occur between 7 and 9 a.m. (22.9%), between 1 and 3 p.m. (15.4%) and between 5 and 7 p.m. (13.5%). The tariff groups most affected are those in Miscellaneous (mainly services). As regards night-time accidents (between midnight and 5 a.m.), the prevalence is also in Miscellaneous (52%), followed by Transport and Agriculture.

Table 3.10 - Injury claims due to road accident occurred at work in Industry and Services by large tariff group and hour of the event. Year 2018 (percentage values)

Large tariff group	1-6	7-12	13-18	19-24	Total
Agricultural processing	19.4	36.5	34.4	9.0	100.0
Chemistry	12.7	36.0	41.4	9.9	100.0
Construction	9.6	41.7	41.1	7.5	100.0
Electricity	3.5	56.6	36.3	3.5	100.0
Wood and related	8.6	47.1	38.6	5.7	100.0
Metallurgy	9.4	39.9	43.2	7.5	100.0
Mining	19.4	36.7	37.4	6.5	100.0
Textiles and clothing	8.6	44.1	42.2	5.1	100.0
Transport	15.4	35.1	37.5	10.6	100.0
Miscellaneous	7.0	44.9	36.8	10.5	100.0
Total (a)	**9.0**	**42.1**	**38.2**	**10.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work related road accidents' archive
(a) The total contains the undefined cases.

4. Discussion

The analysis of the integrated data of the general road accidents collected by Istat and the work-related ones registered by Inail, allows focussing on new interesting data.

The record linkage between different sources has been cited in other articles in literature too (Boufous *et al.*, 2006 and 2009; Adminaite *et al.*, 2017).

The findings contribute to cover the gap in knowledge in the area of work-related road accidents and highlight the most serious injuries and the consequent risk of permanent disability and death. In the study emerges that the injury claims due to work-related road accidents mainly refers to the commuters (about 78%), consequently, in average, only one in five injury claims involves an on-duty driver. The private cars and motorbikes represent the means of transport with the highest number of fatal road traffic accidents and consequently the highest number of survivor claims (39.3% and 26.8% respectively). Especially for the Powered Two Wheels, vehicles without external protections, in 43% of accidents, a permanent disability and hence a direct pension is awarded. Important joined information, not currently available, but contained in the integrated dataset, are the type and the body region of the injury connected with the type of vehicle and the dynamic of the accident (Schick *et al.*, 2019).

Finally, the proportion of commuting road accidents (78%) and those occurring on duty (22%), in the integrated database, follows the same percentages recorded in the original Inail archives. This is an encouraging result for the validity of the results.

The study indeed demonstrates the value of record linkage techniques in addressing some of the limitations of work-related data systems and road accidents archives and in providing a more complete picture of the circumstances of occupational road accidents.

Another important element emerged is that men (workers) receive more compensation (64%) whatever the type of vehicle involved, while women (workers) receive more compensation than their men colleagues, when the vehicle involved is a passenger car (50.5% compared with 49.5%). Besides, a cross-section of the data by type of vehicle involved and the nature of the

injury resulting from the accident, results show that the majority of accident events give rise to injuries of the contusion, fracture and dislocation-distortion type. Users of motorcycles and bicycles had, as a main cause of injury, contusions and fractures (respectively 41.8% and 56.3% for motorcyclists and 39.1% and 27.1% for bike-riders), mostly involving the upper and lower limbs, chest, internal organs and the head.

Accidents involving trucks and passenger cars mainly involved dislocations and sprains (48% and 59.8% respectively), with 3 out of 4 cases involving the spinal column and a smaller percentage involving the head.

Looking at the "nature of the accident" and the damage emerges that the most dangerous accidents, which account for 87% of all fatal accidents, are mainly due to: running off the road (13.4%), head-on collision (24.1%), frontal-lateral collision (27.5%), rear-end collision (14.1%) and collision with an obstacle (8.2%).

The analysis of injury claims occurred at work, specifically in Industry and Services, the main group represented, provide interesting results if read by pricing risk large group and geographical distribution.

In particular, the road accidents at work in "Agricultural processing" and in "Electricity" group occurs mainly in the Centre (respectively 28% and 25.5% out of total of the pricing group). Besides, the "Construction" pricing risk group, "Metallurgy", "Mining", "Textiles, and clothing" record the highest number of road accidents at work in the North-East area (26.7%, 34.7%, 41.2% and 25.9%). For "Chemistry" and "Transport", the peak of the distribution is detected for the North-West (40% and 33.6%). In the South and Islands, the percentages of work-related road accidents are lower than in the other territorial areas.

As regards the choice not to use, in this article, indicators and relative indices (*e.g.* accidents/number of employees) by sector of economic activity and groups of tariffs, it is due to the nature of the denominators available, consisting of estimated values and which could introduce a bias.

The Inail statistical archive contains, indeed, only the employee-year information (units of work per year) for Industry and Services, which is based on estimation of the incomes that the employer declares to pay, with reference to the work performed. In particular, employee's amount, is obtained by

the ratio between the declared incomes and the average daily salary for 300 (theoretical number of working days per year in 52 weeks, excluding Sundays and national holidays). Self-employed workers (owners, partners and housekeeper), on the other hand, are given by the "insured heads". The number of Employees-year does not include those categories of workers (*e.g.* apprentice artisans and non-artisans, members of cooperative, *etc.*) for which salaries are not recognised, due to the "insurance bonus" not linked to them; "temporary" workers (former temporary workers) are also excluded from the count. Furthermore, with regard to multi-location companies (*e.g.* large companies with several workplaces), the employees are generally attributed to the parent office. The ATECO classification of the economic activities is attributed to the company as a whole, regardless of the work actually carried out by the workers.

5. Conclusions

Linked administrative databases offer, in general, a powerful resource for studying important issues. Specifically, the integration of the databases on road accidents and work-related road accidents provides an enriched base of new elements not available otherwise to address policies and interventions useful for both general road safety and safety at work.

The goal of data integration underlying the descriptive analysis presented in this work is the enrichment of existing public statistics. By putting together two data sources that have in common the accidents (with deaths and injuries) occurring on public roads and with means of transport, it is possible to complete the information on the person involved. Information relating to the accident and to the work aspect can be attributed to the person involved in the accident, whether injured or deceased, enriching the knowledge on road accidents related to work allows to work on aspects that were not planned neither on the general accident side nor on the work-related one.

For public statistics, the possible integration of data that can be done with other sources is an opportunity not to be missed.

Future work developments may involve other data sources. It could be thought of connecting data sources that contain detailed information on the vehicle involved in the accident as age and maintenance. The data linking considered in this work is done on individual data. For better understanding the context in which related work accidents occur, it might be useful to include contextual data in the study. Aggregate context data could also be considered such as the territorial working fabric, the offer of urban mobility, road maintenance. Methods developed and implemented in several dominions have achieved high-quality linkages for conducting health, safety and social research and to enhance the potential of the two individual sources.

The performance of the applied record linkage has also led to satisfactory results, such as to imply a replicability of the experience also for the years to come.

Finally, the use of these techniques is in line with the strategy implemented by the main official statistical Institutes, especially, in recent years, for the enhancement of existing administrative archives, aimed at both reducing the statistical burden on respondents, and eliminating redundancies in data dissemination.

Appendix

Table A1 - Injury claims due to road accidents by event and type. Years 2014-2018 (absolute value)

Type of accident	Fatal event	Non-fatal event	Total
		2014	
Commuting road accident *in itinere*	216	19,230	19,446
Accident occurred in the course of work	158	5,779	5,937
Total	**374**	**25,009**	**25,383**
		2015	
Commuting road accident *in itinere*	243	18,918	19,161
Accident occurred in the course of work	172	5,491	5,663
Total	**415**	**24,409**	**24,824**
		2016	
Commuting road accident *in itinere*	208	20,066	20,274
Accident occurred in the course of work	146	5,627	5,773
Total	**354**	**25,693**	**26,047**
		2017	
Commuting accident - Fatal event	214	20,012	20,226
Accident occurred in the course of work - Non-fatal event	150	5,496	5,646
Total	**364**	**25,508**	**25,872**
		2018	
Commuting road accident *in itinere*	250	20,694	20,944
Accident occurred in the course of work	176	5,591	5,767
Total	**426**	**26,285**	**26,711**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Table A2 - Injury claims due to road accidents by event and age classes. Year 2018 (%)

Age (years)	Fatal event	Non-fatal event	Total
Up to 34	27.5	34.8	34.6
35 - 49	35.0	38.4	38.4
50 - 64	34.3	25.6	25.8
65 +	3.1	1.2	1.2
Total	**100.0**	**100.0**	**100.0**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Table A3 - Claimed road accidents by vehicle type and event outcome. Event year 2018 (absolute value)

Event	Truck	Passenger car	Motorcycle	Bicycle	Other vehicle
Fatal event	67	172	128	15	44
Non-fatal event	1,960	14,395	6,247	1,567	2,116
Total	**2,027**	**14,567**	**6,375**	**1,582**	**2,160**

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Table A4 - Contingency tables analysis and statistics on the association between the main categorical variables of the database and the year of event. Years 2014-2018

Statistical Test and variables	Degrees of Freedom	Value	Probability
Statistics for Type of event - Table of by Year			
Chi-Square	4	117198	0.0196
Likelihood Ratio Chi-Square	4	116593	0.0201
Mantel-Haenszel Chi-Square	1	0.0017	0.9668
Phi Coefficient		0.0095	
Contingency Coefficient		0.0095	
Cramer's V		0.0095	
Statistics for "Commuting"/"Accident in the course of work" by Year			
Chi-Square	4	324192	<.0001
Likelihood Ratio Chi-Square	4	323245	<.0001
Mantel-Haenszel Chi-Square	1	312294	<.0001
Phi Coefficient		0.0159	
Contingency Coefficient		0.0159	
Cramer's V		0.0159	
Statistics for Age by Year			
Chi-Square	336	7467411	<.0001
Likelihood Ratio Chi-Square	336	7572584	<.0001
Mantel-Haenszel Chi-Square	1	421660	<.0001
Phi Coefficient		0.0761	
Contingency Coefficient		0.0759	
Cramer's V		0.0381	
Statistics for Gender by Year			
Chi-Square	4	83020	0.0811
Likelihood Ratio Chi-Square	4	83043	0.0810
Mantel-Haenszel Chi-Square	1	60110	0.0142
Phi Coefficient		0.0080	
Contingency Coefficient		0.0080	
Cramer's V		0.0080	
Statistics for Tariff categories for compensation by Year			
Chi-Square	952	17298349	<.0001
Likelihood Ratio Chi-Square	952	17320166	<.0001
Mantel-Haenszel Chi-Square	1	92500	0.0024
Phi Coefficient		0.1162	
Contingency Coefficient		0.1154	
Cramer's V		0.0581	

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Table A4 continued **- Contingency tables analysis and statistics on the association between the main categorical variables of the database and the year of event. Years 2014-2018**

Statistical Test and variables	Degree of Freedom	Value	Probability
Statistics for Localisation of the accident by Year			
Chi-Square	36	2144386	<.0001
Likelihood Ratio Chi-Square	36	2137126	<.0001
Mantel-Haenszel Chi-Square	1	302096	<.0001
Phi Coefficient		0.0408	
Contingency Coefficient		0.0408	
Cramer's V		0.0204	
Statistics for Table of Geographical Macro-region by Year			
Chi-Square	16	727546	<.0001
Likelihood Ratio Chi-Square	16	735020	<.0001
Mantel-Haenszel Chi-Square	1	162837	<.0001
Phi Coefficient		0.0238	
Contingency Coefficient		0.0238	
Cramer's V		0.0119	
Statistics for Table of Month by Year			
Chi-Square	44	2187552	<.0001
Likelihood Ratio Chi-Square	44	2193183	<.0001
Mantel-Haenszel Chi-Square	1	70587	0.0079
Phi Coefficient		0.0412	
Contingency Coefficient		0.0412	
Cramer's V		0.0206	
Statistics for Nature of accident by Year			
Chi-Square	44	1694103	<.0001
Likelihood Ratio Chi-Square	44	1663928	<.0001
Mantel-Haenszel Chi-Square	1	30231	0.0821
Phi Coefficient		0.0363	
Contingency Coefficient		0.0362	
Cramer's V		0.0181	
Statistics for Nature of injury by Year			
Chi-Square	32	872429	<.0001
Likelihood Ratio Chi-Square	32	884873	<.0001
Mantel-Haenszel Chi-Square	1	201434	<.0001
Phi Coefficient		0.0280	
Contingency Coefficient		0.0280	
Cramer's V		0.0140	

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

Table A4 continued **- Contingency tables analysis and statistics on the association between the main categorical variables of the database and the year of event. Years 2014-2018**

Statistical Test and variables	Degree of Freedom	Value	Probability
Statistics for Time (hour) by Year			
Chi-Square	96	2131427	<.0001
Likelihood Ratio Chi-Square	96	2136345	<.0001
Mantel-Haenszel Chi-Square	1	18593	0.1727
Phi Coefficient		0.0407	
Contingency Coefficient		0.0406	
Cramer's V		0.0203	
Statistics for Role of injured/dead by Year			
Chi-Square	8	127114	0.1222 (a)
Likelihood Ratio Chi-Square	8	126120	0.1259
Mantel-Haenszel Chi-Square	1	40153	0.0451
Phi Coefficient		0.0099	
Contingency Coefficient		0.0099	
Cramer's V		0.0070	
Statistics for Injury Site by Year			
Chi-Square	260	3475359	0.0002
Likelihood Ratio Chi-Square	260	3499807	0.0002
Mantel-Haenszel Chi-Square	1	282354	<.0001
Phi Coefficient		0.0559	
Contingency Coefficient		0.0558	
Cramer's V		0.0279	
Statistics for Compensation type by Year			
Chi-Square	16	1524017	<.0001
Likelihood Ratio Chi-Square	16	1516563	<.0001
Mantel-Haenszel Chi-Square	1	361649	<.0001
Phi Coefficient		0.0344	
Contingency Coefficient		0.0344	
Cramer's V		0.0172	
Statistics for Vehicle type by Year			
Chi-Square	76	2200422	<.0001
Likelihood Ratio Chi-Square	76	2226930	<.0001
Mantel-Haenszel Chi-Square	1	52514	0.0219
Phi Coefficient		0.0421	
Contingency Coefficient		0.0420	
Cramer's V		0.0210	

Source: Authors' processing on integrated Istat and Inail work-related road accidents' archive

(a) All the main variables of the database show an independence in the distribution, with respect to the year of the event. Only for the variable "Role of injured/dead" in the accident (Driver, Passenger, Pedestrian), the chi-square test leads to a probability associated to the corresponding p-value equal to 0.122 (Low significance level, if it is considered the hypothesis H0 of independence of the variables in the statistical test). The final decision of the authors was to focus the analysis, however, only on the year of event 2018, as representative of the whole period, due to the result of the mentioned chi-square test is conditioned by a slight difference in the proportion of passengers, observed in 2014.

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