An analysis of work-related road injuries by macro-economic sector, road type and Italian territorial divisions

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Abstract

Information about accidents is essential for studying road safety: work-related journeys constitute a significant part of traffic problems. By linking data from the archives of both the Italian National Institute for Insurance against Accidents at Work - Inail and the Italian National Institute of Statistics - Istat, we were able to analyse approximately 129,000 work-related road accidents that occurred in Italy during the period 2014-2018.

The nationwide study investigated on injury rates by road type and economic sector, otherwise not available in the two archives separately.

Injury rates within and between Italian territorial divisions were analysed by spatial, descriptive analysis and analysis of variance - ANOVA. Maximum injury rates were found in the sales, metals and machinery, transport and warehouses, health and social services, construction and plant sectors. Indexation using the ratio of accident frequencies and the number of employees was useful for expressing a dynamic assessment of how many work-related road injuries "derive" from the total number of workers employed in a sector. ANOVA analysis showed that injury variances on rural and urban roads, as well as in macro-economic sectors differed in Italian

territorial divisions. This study is also intended for local public health authorities responsible for assessing and managing risks in specific contexts.

Keywords: Work-related road injuries, territorial division, macro-economic sector, road type, ANOVA.

1. Introduction

Data about accidents provide essential information for road safety (Hollò *et al.*, 2010). The causality of work-related road (W-RR) accidents is essential since the journey from home to work (commuting) accounts for a significant part of urban and rural traffic.

A recent study analysed 20,941 W-RR accidents by linking data concerning general road accidents registered by the Italian National Institute of Statistics (Istat) and occupational accidents registered by the Italian National Institute for Insurance against Accidents at Work (Inail) that occurred in Italy in 2015 (Brusco *et al.*, 2019).

The disparity between the two integrated archives, which emerged from the same study, was related to the incomplete nature of the records. Over the years, the addition of more detailed data has reduced this gap. A further reason for a lack of correspondence between the two archives was attributable to a failure to collect information on the injured person and on the real reasons for his/her journey.

Despite these limitations, for the first time in Italy the 2015 study assembled in a single dataset both occupational information on road user injuries and the context of the road accident. Currently, no other archives containing occupational and contextual information on accidents are available in Italy. To fill this gap, a new integrated dataset of W-RR accidents, based on a longer period of observation and containing about 129,000 records on collisions resulting in death or injury, has been made (Bruzzone *et al.*, 2021; Taiano *et al.*, 2021).

We conducted an analysis designed to evaluate the variance of approximately 129,000 injuries by road type (Legislative Decree 30 April 1992 n. 285/*Decreto legislativo* n. 285/1992) and macro-economic sector in Italian territorial divisions. This included an analysis of road and accident data, a thorough spatial descriptive analysis of W-RR injuries by macro-economic group, road type and location, integrated with an analysis of variance (ANOVA), which provided variance associated the two accident parameters (road type and macro-economic sector), within and between and the 5 Italian territorial divisions. This study is also intended for professionals in the territorial divisions who are responsible for assessing and managing risks in specific contexts.

2. Data source

2.1 The Italian situation

The Italian territory extends for 302,073 sq. km (Istat, 2018), and is divided into five territorial areas: the North West (approx. 58,000 sq. km), the North East (62,000 sq. km), the Centre (58,000 sq. km), the South (74,000 sq. km) and the Islands (50,000 sq. km). Roads, widely distributed over these five Italian divisions (*OpenStreetMap* data) stretch for about 128,000 km in the North West (2.2 km of infrastructure per sq. km), 131,000 km in the North East (2.11), 114,000 km in the Centre (1.96), 147,000 km in the South (2.01) and 76,000 km in the Islands (1.52). The number of "estimated workers per year"[3] was over 17,000,000 in 2018 (6,237,773 in the North West, 4,047,193 in the North East, 3,958,636 in the Centre, 2,163,973 in the South and 979,553 in the Islands). In 2018, over 172,000 road accidents in Italy resulted in 3,334 deaths (within 30 days) and over 240,000 injuries (source Istat and the Police force). During the five-year period 2014-2018, Istat recorded a total number of 874,847 road accidents involving about 1,253,715 persons injured or dead (254,528 persons in 2014 and 246,253 in 2018), since the single accident, both work-related and non-work-related, certainly, is associated with one or more injured or dead persons (Istat, 2021*a*).

Approximately 15% of the over 600,000 work accidents reported to Inail in 2018 were road accidents. During the five-year period 2014-2018, 465,943 work-related road injuries were recorded by Inail (93,056 in 2014 and 94,553 in 2018). According to Inail data, each injured person was associated with only one traffic accident.

Between these two data sources, there is an "intersection set" based on road injuries present in both the Istat and the Inail archives.

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3 Inail data. For Industry and Services in both ATECO and LARGE TARIFF GROUPS (macro-economic sector), Inail estimates employees per year as the ratio between declared wages and the average daily wage per 300 (theoretical number of working days per year excluding holidays). Self-employed workers, apprentices, craftsmen and non-craftsmen, and members of porters' or fishermen' cooperatives are excluded from this total as are undefined categories. Furthermore, in companies with branches all over Italy, all employees are generally assigned only to the headquarters. Finally, in Italy, the ATECO classification assigns the same Class to each worker of each company. Data available on the URL: https://www.inail.it/cs/internet/attivita/dati-e-statistiche/banca--dati-statistica.html. 2018, Updated to 31/10/2020.

2.2 The Inail and Istat archives

RELAIS (REcord Linkage At IStat) integration of the data linkage between the Inail archives on work-related accidents and the Istat archives concerning road accidents resulting in death or injury revealed 128,837 injuries (drivers, passengers or pedestrians, injured or dead within 24 hours or in the first 30 days following the accident) that occurred in Italy in the period from 2014 to 2018. The integrated dataset encompasses complementary information, as the former expresses occupational parameters while the latter refers to road accident parameters.

The Istat archives contain, indeed, complete data on all reported collisions (Istat data warehouse I.Stat. 2014-2018, 2019) on Italian roads involving at least one vehicle. The Istat archives contain the most complete and accurate information available about road accidents in Italy and include accident parameters such as road type, road user or driver, vehicle type and environment as well as the geographic coordinates of the road point where the collision occurred (Pireddu and Bruzzone, 2021).

The Inail archives contain the most complete and accurate information available about work-related road accidents in Italy. The archives cover about 80% of the Italian workforce (Inail, 2019), but do not include those employed in the armed forces, fire brigades, the police force, air transport personnel, independent traders and professionals with VAT registration (Gariazzo *et al.*, 2021). The Inail archives include the social (injury claims due to work-related road accidents and compensation data for injured workers or their families in case of death) as well as the occupational parameters of workers and the relevant economic sector of activity, in addition to information on the involvement or non-involvement of a vehicle at the time of the accident, which are classified as injuries *at work* and during *commuting*.

The occupational variables, such as the activity in which workers are engaged, are classified into two groups: ATECO (Istat) and LARGE TARIFF GROUP[4] or macro-economic sector (Inail). The former is the Italian standard

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4   Large tariff group refers to the highest class aggregating items of the 4 tariffs applied to the management of industry and services (industry, crafts, tertiary, other activities). There are 10 classes that conglomerate the processes of each large tariff group (macro-economic sector) according to homogeneous production sectors (1. agricultural processing and food; 2. chemical, paper and leather; 3. construction and plants; 4. energy and communications; 5. wood and the like; 6. metals and machinery; 7. mining, minerals and glass; 8. textiles and

classification of productive economic activities derived from the *Nomenclature générale des Activités économiques dans les Communautés Européennes* (Vicari *et al.*, 2007). Some critical issues are connected with ATECO on account of the significant number of undefined cases. Furthermore, according to the ATECO classification, the geographic location of each workplace frequently indicates the location of the company headquarters and not the place where the worker actually commutes from home to work or drives around during on-duty service. For each company in Italy, the ATECO classification assigns the same code to all its workers, regardless of the activity actually carried out by each employee. These aspects could cause distortions that affect spatial analysis indexing[5] and the calculation of rates by sectors if several units are distributed all over the country.

On the other hand, the classification of work activity by macro-economic sector (see Footnote 1) is more consistent with the work actually carried out by the injured person and with the location where the worker commutes from home to work or where the accident takes place. Although this classification is partially incomplete due to undefined cases, it was more suitable for our analysis. Therefore for the purposes of this study, only the Inail classification by macro-economic sector was used.

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packaging; 9. transport and warehouses; 10. various activities). The large tariff group may contain different items for different tariffs. Technical reference: [Inail-010b, 11]. Url: https://dati.inail.it/opendata/default/Infortuni/index.html. For the purpose of this study "macro-economic sector" is used instead of "Large tariff group".

5   The W-RR injury index by province and macro-economic sector, based on the estimated number of employees (see footnote 1) is calculated using the formula (1) Index = N° W-RR Injuries/ N° Employees by macro-economic sector.

3. Methods

Data concerning approximately 129,000 W-RR accidents that occurred in Italy in the period from 2014 to 2018 were analysed. The study included a descriptive and detailed spatial analysis (Cima *et al.*, 2014; Costabile *et al.*, 2012) of accidents aggregated by economic sector, location and road type and a One Way Analysis of Variances (ANOVA) of W-RR injuries by road type and macro-economic sector (see Footnote 1), between and within the 5 aforementioned Italian territorial divisions. ANOVA is an inferential technique which, when applied to two or more groups of data, enables us to compare internal variability with variability between the groups. This technique assumes that variance can be divided into two components: within groups and between groups. The null hypothesis (H_0) commonly assumes that the data of all groups have the same stochastic distribution and that the observed differences between the groups are due to randomness. This division of variance is based on the hypothesis that the differences in W-RR injuries can be explained by the characteristics of the group to which they belong (*i.e.* Italian territorial divisions). When variance between groups contributes significantly to total variance, it can be accepted that the observed difference is linked to the characteristics of the group. Vice versa, when the variance within groups contributes significantly to the total variance, the observed differences can be considered to be linked to the specific case.

The variables analysed were: the macro-economic sector (sales; reception and catering; health and social services; cleaning, sanitation and disinfestation; cinematography, culture and sport; education, research and survey; various and undefined activities; agriculture and food processing; chemical, paper and leather; construction and installation; energy and communications; wood and the like; metals and machinery; mining, minerals and glass; textiles and packaging; transport and warehouses; not classified; public administration; service personnel and students); the road type (motorway; rural road; urban road); the Italian provinces and territorial divisions (the North West; the North East; the Centre; the South; the Islands).

Among the former we analysed and indexed (Hollò *et al.*, 2010) the most relevant in terms of frequency and means *i.e. GG01 sales, GG03 health and social services, G3 construction and installation, GG6 metals and machinery, GG9 transport and warehouses*. The indicators used for the analysis were

based on the ratio between the number of accidents and the estimated number of employees in each macro-economic sector (1) Number of W-RR Injuries / Estimated number of employees.

Inail calculates the number of employees using the ratio of the total amount of wages declared and the average daily wage per 300 (theoretical number of working days per year, excluding holidays). For our analysis, the estimated number of employees used in formula (1) was based on the aforementioned Inail criterion. This estimate excluded certain types of workers and undefined cases (see Footnotes 1 and 3).

Our study included a spatial analysis and mapping referring to the macro-economic sector, suitable for a preliminary data investigation. ANOVA (Lix *et al.*, 1996) was applied to the same variables used for descriptive analysis: road type, macro-economic sector and territorial area. The absolute and relative W-RR injury variances were calculated by road type and macro-economic sector between and within the 5 Italian territorial divisions (Table 4.1). At this point, the spatial and descriptive analyses were completed using ANOVA and the Kruskall-Wallis test. The findings are reported below. Spatial analysis was performed using *Quantum Geographic Information System* (QGIS version 3.20.3), whereas ANOVA was performed using *Rstudio* (version 3.18.3) and *PSPP* (version 0.10.5).

4. Results

4.1 Descriptive analysis

The absolute frequencies of W-RR injuries were 42,017 in the North West and 40,920 in the North East, totalling 82,937 units. The Centre (25,996), the South (12,894) and the Islands (7,010) registered approximately 45,900 cases (Tables 4.1 and A1 in Appendix A).

Table 4.1 - Injury frequencies by macro-economic sector, territorial division and road type (absolute values). Five macro-economic sectors. Italy. 2014-2018

Macro-economic sector	Territorial division	Motorway	Rural road	Urban road	Total
GG01 Sales	Centre	215	677	1,459	2,351
	Islands	62	245	513	820
	North East	170	1,007	2,209	3,386
	North West	358	941	2,413	3,712
	South	74	482	601	1,157
	Italy	879	3,352	7,195	11,426
GG03 Health social services	Centre	156	549	1,264	1,969
	Islands	59	261	443	763
	North East	77	790	1,945	2,812
	North West	203	728	2,251	3,182
	South	72	480	683	1,235
	Italy	567	2,808	6,586	9,961
GG3 Construction and plant	Centre	242	600	906	1,748
	Islands	36	160	206	402
	North East	236	961	1,285	2,482
	North West	450	809	1,438	2,697
	South	108	449	326	883
	Italy	1,072	2,979	4,161	8,212
GG6 Metals and machinery	Centre	132	566	1,141	1,839
	Islands	26	87	157	270
	North East	162	1,432	2,610	4,204
	North West	327	1,127	2,776	4,230
	South	54	367	347	768
	Italy	701	3,579	7,031	11,311
GG9 Transport and warehouses	Centre	476	721	999	2,196
	Islands	72	183	244	499
	North East	641	1,034	1,511	3,186
	North West	688	1,061	1,917	3,666
	South	212	543	417	1,172
	Italy	2,089	3,542	5,088	10,719

Source: Authors' processing on integrated Inail - Istat archive data. Italy 2014-2018

Details about annual injury frequency are reported in an accompanying paper (Bruzzone *et al.*, 2021).

Figure 4.1 - W-RR injuries by road type and province (absolute values). Italy. 2014-2018
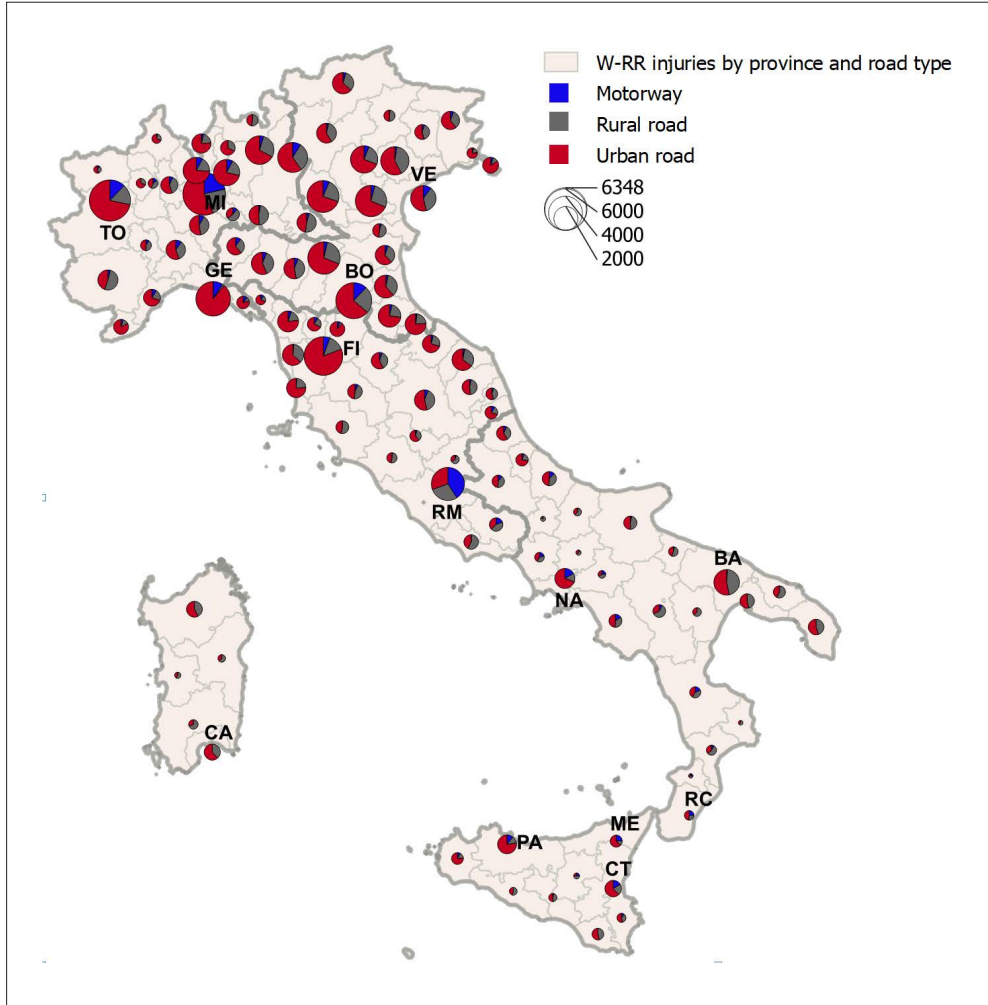
Figure 4.1 illustrates the 107 Provinces (grey), the 5 Italian territorial divisions (dark grey) and the 14 Italian metropolitan areas (initialled - MI, RM, *etc.*). For each province the total absolute W-RR injury frequency rate is symbolised by the pie chart diameter (label), while the three segments of the pie

chart show the percentage of injuries on motorways (blue), rural roads (grey) and urban roads (red). In the same Figure, the three segments of the pie charts show the different distribution in the Provinces, and within and between the 5 territorial divisions.

The integrated dataset for 2014-2018 demonstrated that injury rates were 10,639 (6%-19%) for motorways; 37,866 for rural roads (28%-33%) and 80,332 for urban roads (47%-62%). The only exception was represented by the province of Rome (Metropolitan City) where the accident rates were distributed almost equally in the three types of road (Figure 4.1). Previous Inail - Istat record linkage (Brusco *et al.*, 2019) indicated that out of the total number of accidents that occurred in 2015, approximately 3% were on motorways, 19% on rural roads and 78% on urban roads.

Table 4.2 - Descriptive Statistics. W-RR injuries by road type and territorial division (absolute values). (95% Confidence Interval for Mean). Italy. 2014-2018

Road type	Territorial division	Province (N)	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min.	Max.
Motorway	Centre	22	120.09	326.24	69.56	-24.56	264.74	1	1,556
	Islands	14	37.43	56.34	15.06	4.90	69.96	0	157
	North East	22	105.86	114.18	24.34	55.24	156.49	8	542
	North West	25	165.96	293.55	58.71	44.79	287.13	0	1,363
	South	24	41.46	51.45	10.50	19.73	63.19	0	234
	Italy	107	99.43	215.76	20.86	58.08	140.78	0	1,556
Rural road	Centre	22	340.05	240.97	51.37	233.21	446.88	41	1,087
	Islands	14	161.79	99.95	26.71	104.08	219.49	63	373
	North East	22	561.09	308.38	65.75	424.36	697.82	74	1,125
	North West	25	418.60	344.01	68.80	276.60	560.60	55	1,379
	South	24	221.29	201.41	41.11	136.24	306.34	31	1,044
	Italy	107	353.89	293.19	28.34	297.69	410.08	31	1,379
Urban road	Centre	22	721.50	851.00	181.43	344.19	1,098.81	87	4,213
	Islands	14	301.50	270.68	72.34	145.21	457.79	32	957
	North East	22	1,193.05	773.56	164.92	850.07	1,536.02	220	2,887
	North West	25	1,096.12	1,178.05	235.61	609.85	1,582.39	111	4,249
	South	24	274.50	288.23	58.84	152.79	396.21	15	1,211
	Italy	107	750.77	866.13	83.73	584.76	916.77	15	4,249

Source: Authors' processing on integrated Inail - Istat archive data. Italy 2014-2018

Table 4.3 - Descriptive statistics. W-RR injuries by 5 macro-economic sectors and territorial division (absolute values). (95% Confidence Interval for Mean). Italy. 2014-2018

Macro-economic sector	Territorial division	Province (N)	Freq.	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min.	Max.
GG01 Sales	Centre	22	2,351	106.86	112.93	24.08	56.79	156.94	20	479
	Islands	14	820	58.57	46.65	12.47	31.64	85.51	8	166
	North East	22	3,386	153.91	90.36	19.26	113.85	193.97	28	337
	North West	25	3,712	148.48	145.59	29.12	88.38	208.58	11	521
	South	24	1,157	48.21	47.28	9.65	28.24	68.17	4	230
	Italy	107	11,426	106.79	107.94	10.43	86.10	127.47	4	521
GG03 Health social services	Centre	22	1,969	89.50	86.68	18.48	51.07	127.93	23	389
	Islands	14	763	54.50	40.99	10.95	30.84	78.16	11	132
	North East	22	2,812	127.82	73.06	15.58	95.43	160.21	34	334
	North West	25	3,182	127.28	121.16	24.23	77.24	177.29	19	472
	South	24	1,235	51.46	44.87	9.16	32.51	70.41	8	209
	Italy	107	9,961	93.09	87.35	8.44	76.35	109.84	8	472
GG3 Construction and plant	Centre	22	1,748	79.45	66.88	14.26	49.80	109.11	19	296
	Islands	14	402	28.71	17.96	4.80	18.35	39.08	7	66
	North East	22	2,482	112.82	65.47	13.96	83.79	141.85	21	259
	North West	25	2,697	107.88	92.70	18.54	69.61	146.15	17	341
	South	24	883	36.79	34.92	7.13	22.05	51.54	0	172
	Italy	107	8,212	76.75	71.78	6.94	62.99	90.5	0	341
GG6 Metals and machinery	Centre	22	1,839	83.59	66.11	14.09	54.28	112.9	8	282
	Islands	14	270	19.29	14.37	3.84	10.99	27.58	2	48
	North East	22	4,204	191.09	137.33	29.28	130.20	251.98	47	460
	North West	25	4,230	169.20	184.83	36.97	92.91	245.49	11	665
	South	24	768	32	29.07	5.93	19.72	44.28	1	102
	Italy	107	11,311	105.71	131.63	12.73	80.48	130.94	1	665
GG9 Transport and warehouses	Centre	22	2,196	99.82	124.31	26.50	44.70	154.93	24	534
	Islands	14	499	35.64	27.09	7.24	20.00	51.28	8	83
	North East	22	3,186	144.82	106.79	22.77	97.47	192.16	19	491
	North West	25	3,666	146.64	153.63	30.73	83.23	210.05	9	626
	South	24	1,172	48.83	43.78	8.94	30.35	67.32	7	213
	Italy	107	10,719	100.18	115.06	11.12	78.12	122.23	7	626

Source: Authors' processing on integrated Inail - Istat archive data. Italy 2014-2018

The descriptive analysis based on "accidents by macroeconomic sector (GG) and territorial division" shown in Table 4.3, provides absolute frequencies, averages, standard deviations, standard errors, lower and upper limits of the confidence intervals, minimum and maximum. In all the sectors examined, the highest frequencies and the highest means were found in the North of the country. In particular, the GG6 metal and machinery sector recorded 4,204 cases in the North East and 4,230 cases in the North West

(average 169.20 and mean confidence interval 92.91-245.49). Dispersion peaks (standard deviation) were observed in the North West, while the minimum values for the GG6 metal and machinery sector, the GG9 transport and warehouse sector and the GG01 sales sector were found in the Islands. The minimum standard error and therefore the greatest reliability of data was observed in the Islands for the GG6 metals and machinery sector (3.84) and the GG3 construction and plant sector (4.80).

Table 4.4 - Descriptive statistics. W-RR injuries by macro-economic sector and territorial division (relative values). (95% Confidence Interval for Mean). Italy. 2014-2018

Macro-economic sector	Territorial division	Province (N)	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min.	Max.
GG01 Sales	Centre	22	0,99	0,31	0,07	0,85	1,12	0,4	1,6
	Islands	14	0,72	0,27	0,07	0,57	0,88	0,3	1,2
	North East	22	1,09	0,39	0,08	0,92	1,26	0,6	1,9
	North West	25	1,11	0,59	0,12	0,87	1,35	0,2	2,5
	South	24	0,54	0,27	0,06	0,43	0,66	0,1	1,1
	Italy	107	0,90	0,45	0,04	0,82	0,99	0,1	2,5
GG03 Health social services	Centre	22	1,25	1,04	0,22	0,79	1,71	0,2	3,9
	Islands	14	0,75	0,70	0,19	0,35	1,15	0,2	2,4
	North East	22	0,89	0,43	0,09	0,70	1,08	0,5	2,1
	North West	25	0,80	0,28	0,06	0,68	0,92	0,3	1,5
	South	24	0,43	0,17	0,04	0,36	0,51	0,2	0,7
	Italy	107	0,82	0,64	0,06	0,70	0,95	0,2	3,9
GG3 Construction and plant	Centre	22	0,72	0,24	0,05	0,61	0,83	0,2	1,3
	Islands	14	0,39	0,12	0,03	0,32	0,46	0,2	0,6
	North East	22	0,76	0,22	0,05	0,66	0,86	0,3	1,2
	North West	25	0,66	0,24	0,05	0,56	0,76	0,4	1,3
	South	24	0,36	0,20	0,04	0,28	0,45	0.0	0,8
	Italy	107	0,59	0,27	0,03	0,54	0,64	0.0	1,3
GG6 Metals and machinery	Centre	22	0,73	0,27	0,06	0,61	0,85	0,4	1,6
	Islands	14	0,42	0,16	0,04	0,33	0,51	0,2	0,8
	North East	22	0,69	0,23	0,05	0,59	0,79	0,3	1,1
	North West	25	0,70	0,37	0,07	0,54	0,85	0,3	1,8
	South	24	0,44	0,27	0,05	0,33	0,56	0.0	1,2
	Italy	107	0,61	0,30	0,03	0,55	0,67	0.0	1,8
GG9 Transport and warehouses	Centre	22	2,14	0,97	0,21	1,71	2,58	0,3	4,4
	Islands	14	0,99	0,20	0,05	0,87	1,11	0,8	1,4
	North East	22	1,82	0,60	0,13	1,55	2,08	0,9	3,2
	North West	25	1,96	0,79	0,16	1,63	2,28	0,5	3,8
	South	24	1,09	0,44	0,09	0,91	1,28	0,3	2.0
	Italy	107	1,65	0,81	0,08	1,49	1,80	0,3	4,4

Source: Authors' processing on integrated Inail - Istat archive data. Italy 2014-2018. Inail archives of employed workers, BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (see Footnotes 1, 2 and 3")

Spatial analysis of W-RR injuries by economic group, province and estimated number of the employed provided absolute and relative values (Figures 4.2 - 4.6).

Figure 4.2 - GG01 Sales W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees (a) **and province (below). Italy. 2014-2018**

Macro economic sector	Motorway	Rural road	Urban road	Italy
1 GG01 Sales	879	3352	7195	11426
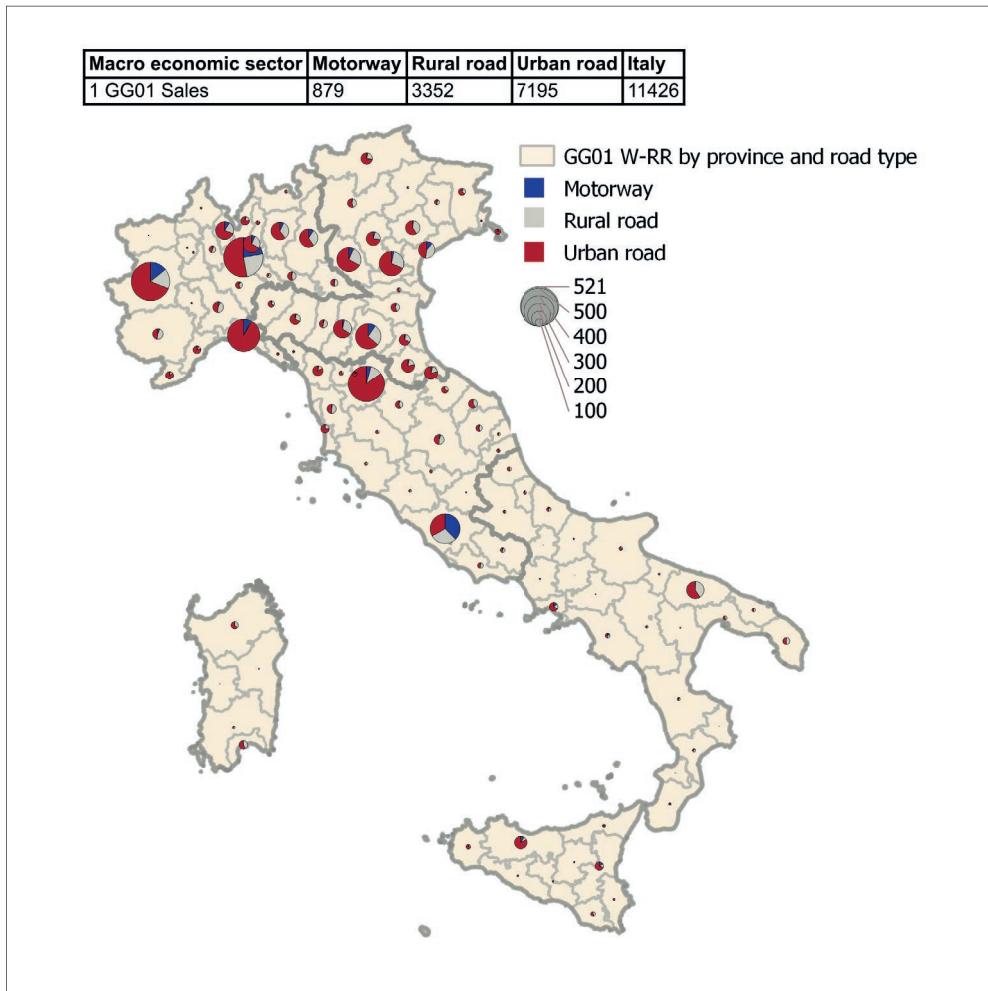
Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS
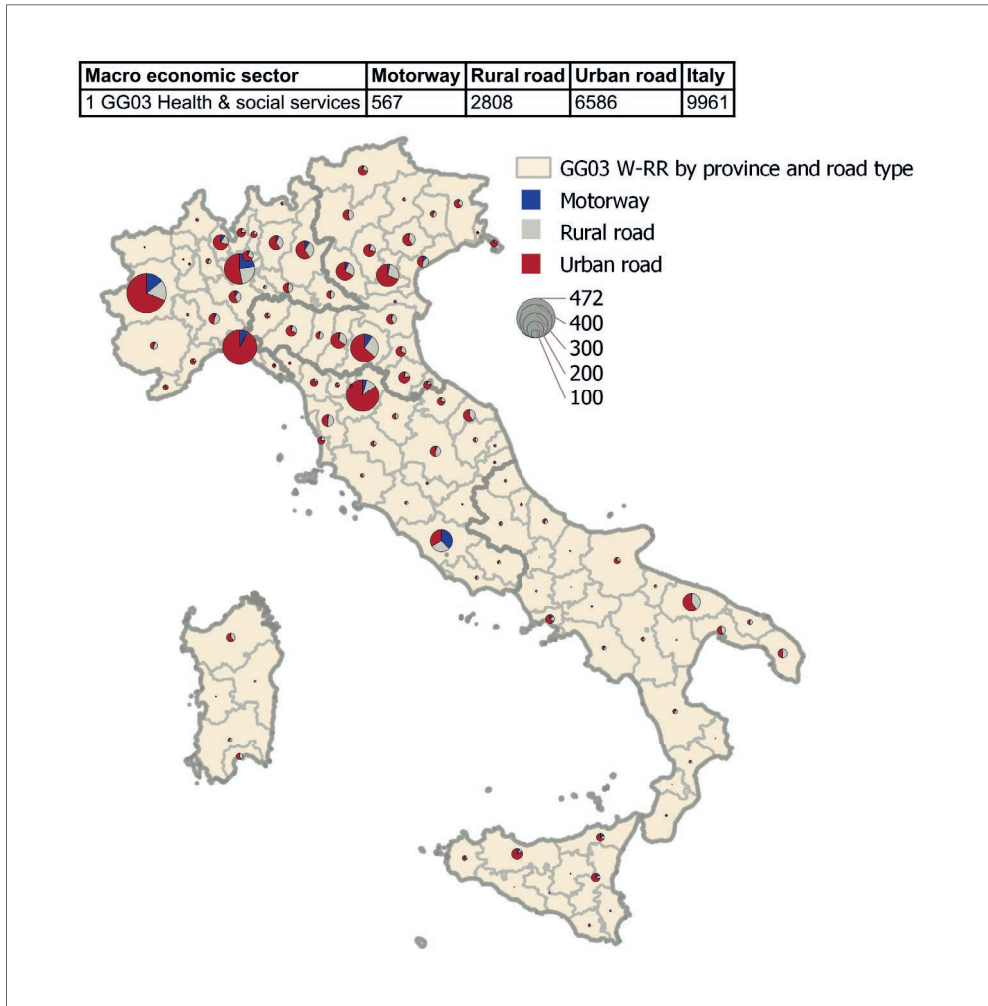(a) See Footnotes 1, 2 and 3.

Figure 4.2 continued **- GG01 Sales W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees** (a) **and province (below). Italy. 2014-2018**
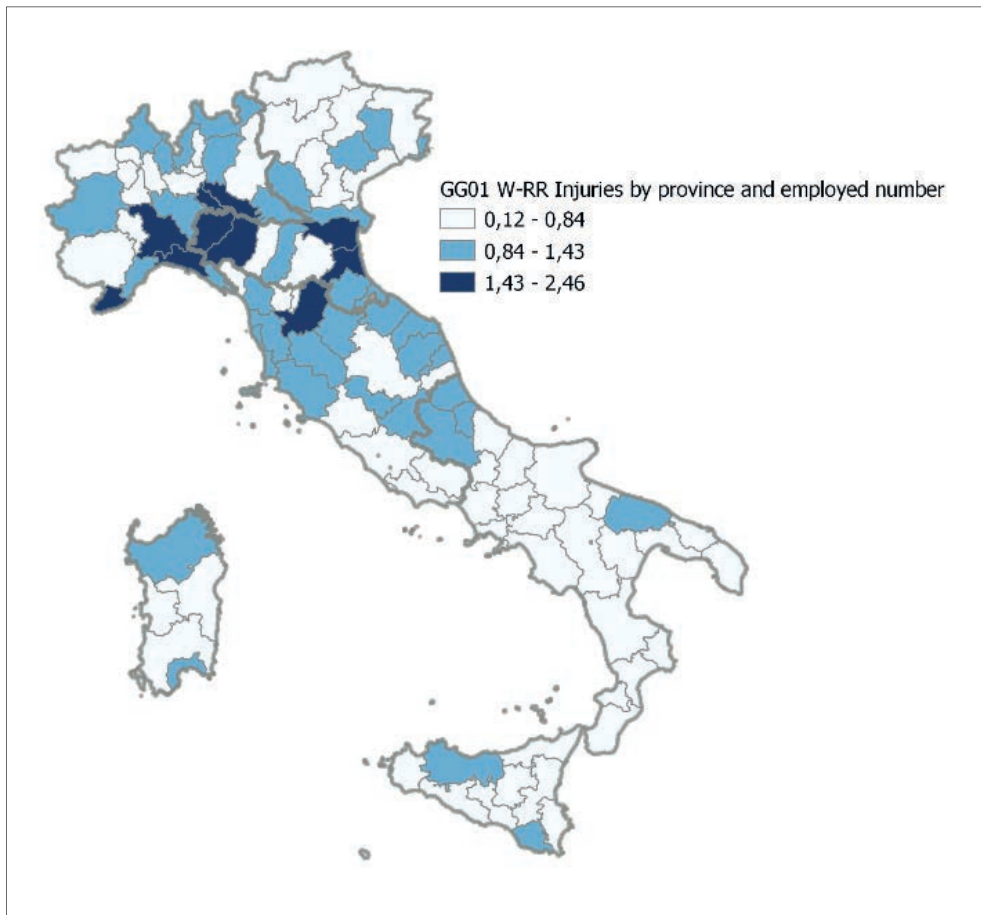
Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS (Jenks)
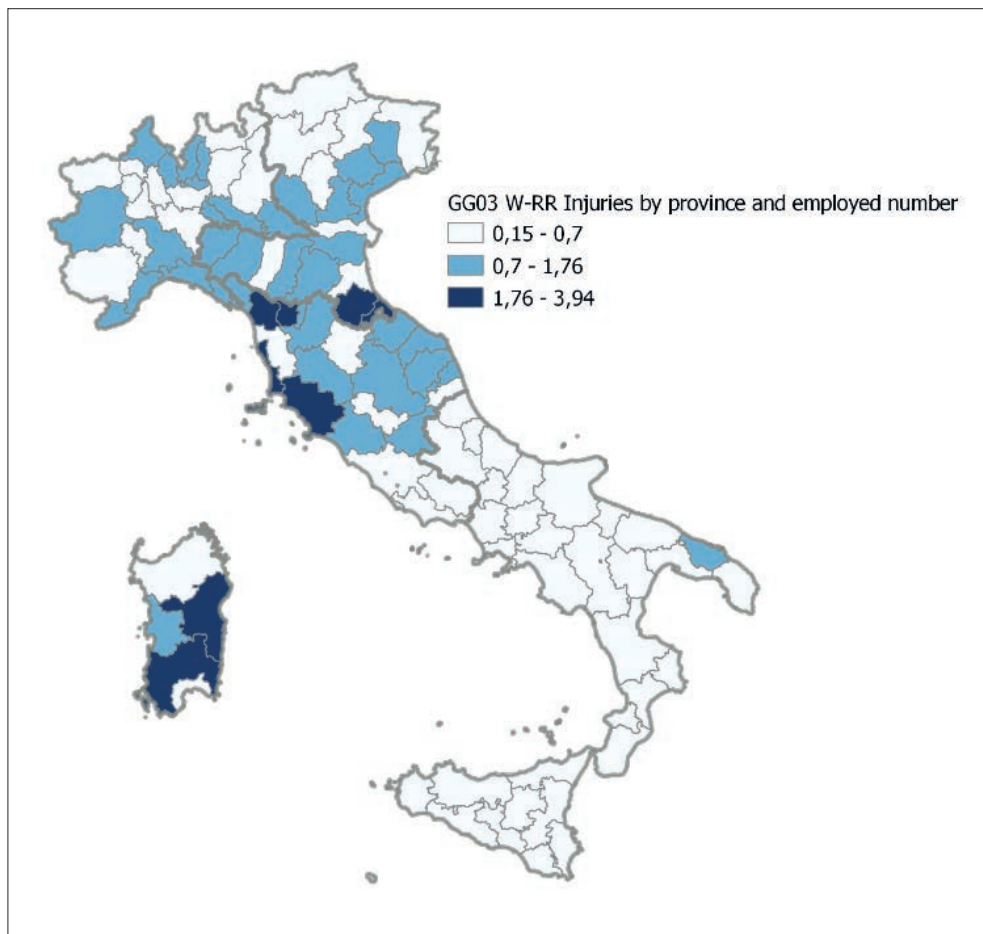
(a) See Footnotes 1, 2 and 3.

Figure 4.3 - GG03 Health and social services W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees and province (below). Italy. 2014-2018

| Macro economic sector	Motorway	Rural road	Urban road	Italy
1 GG03 Health & social services	567	2808	6586	9961

Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS

Figure 4.3 continued **- GG03 Health and social services W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees and province (below). Italy. 2014-2018**
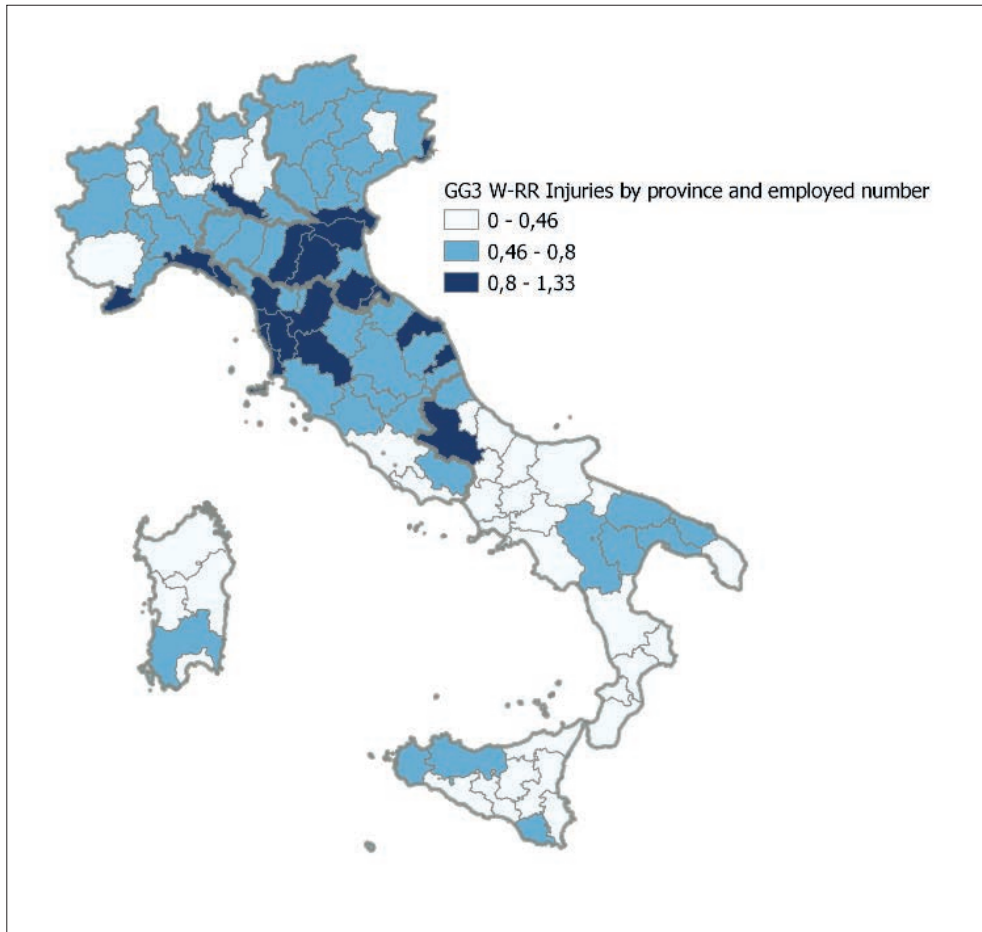

Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS (Jenks)

Figure 4.4 - GG3 Construction and plant W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees and province (below). Italy. 2014-2018

| Macro economic sector	Motorway	Rural road	Urban road	Italy
1 GG3 Construction and plant	1072	2979	4161	8212
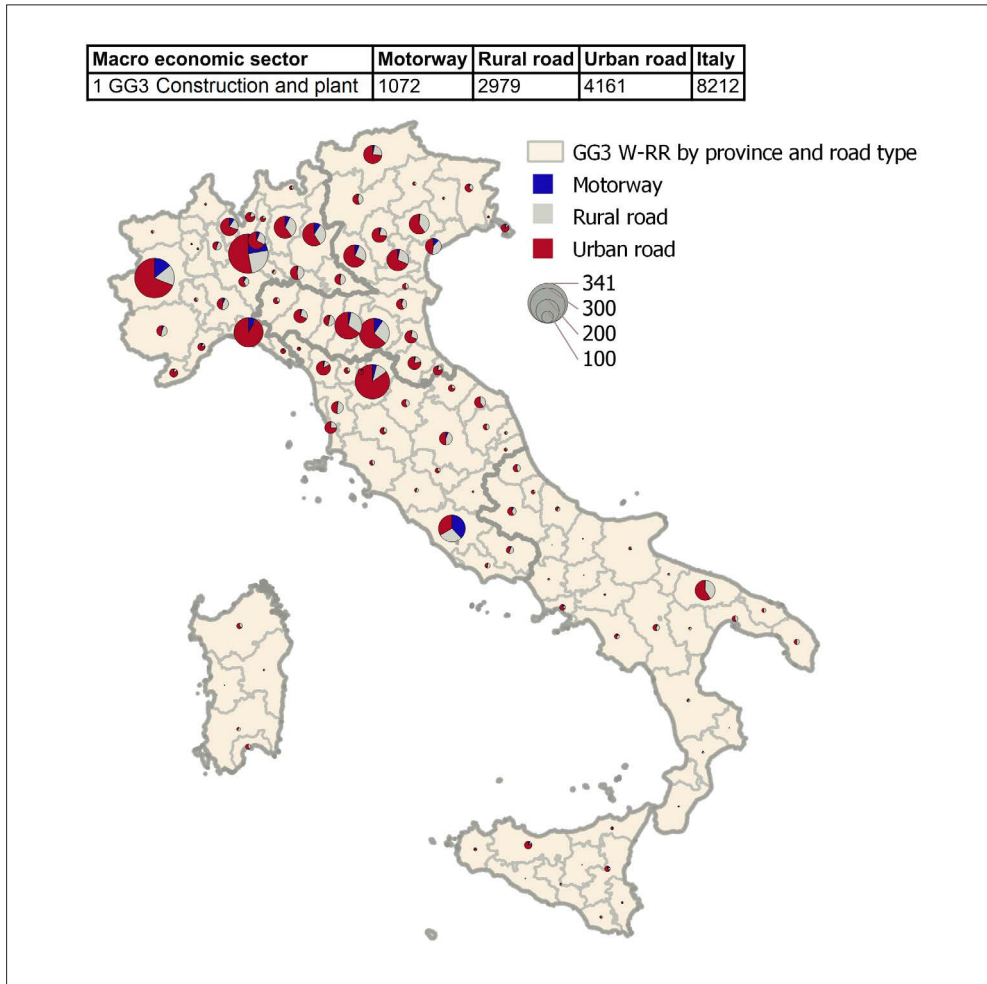
Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS

Figure 4.4 continued **- GG3 Construction and plant W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees and province (below). Italy. 2014-2018**

Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS (Jenks)

**Figure 4.5 - GG6 Metals and machinery W-RR injuries. Table and map of absolute
values by road type and provinces (bottom) and index map by employees
and province (below). Italy. 2014-2018**

| Macro economic sector	Motorway	Rural road	Urban road	Italy
1 GG6 Metals and machinery	701	3579	7031	11311
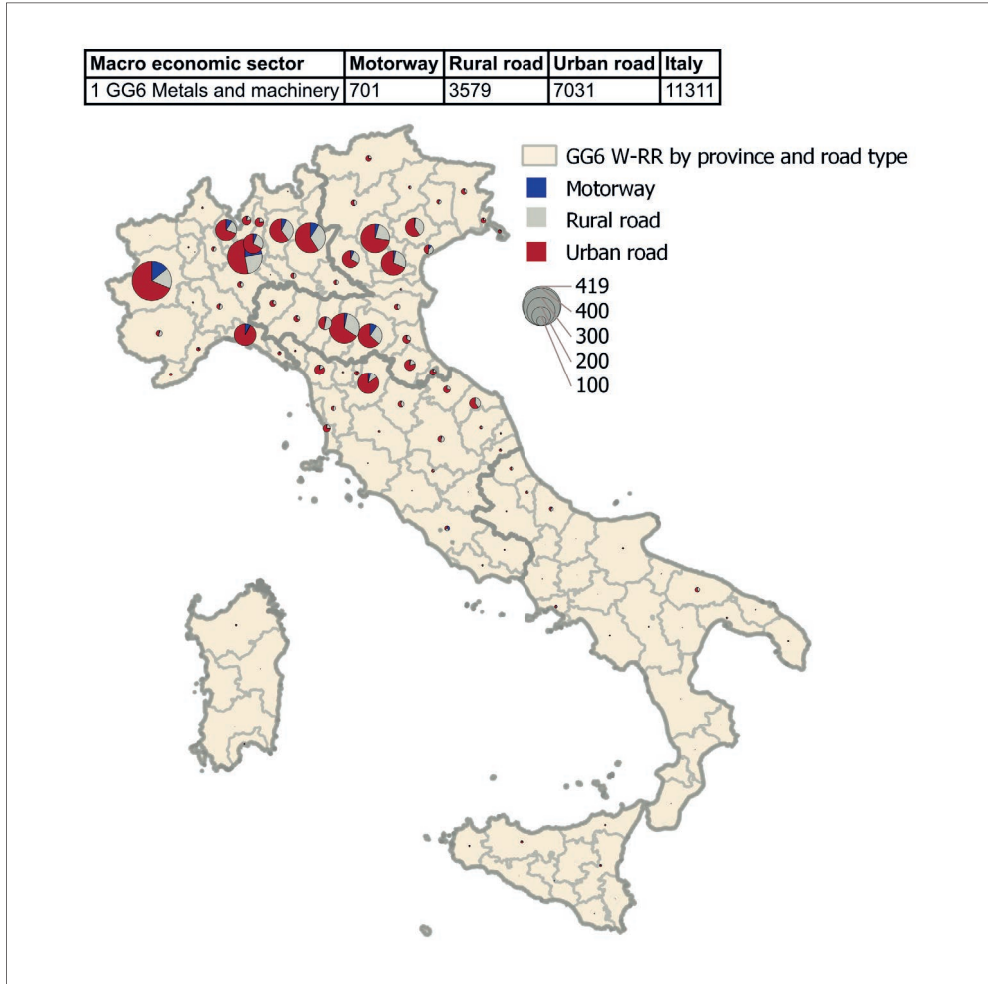
Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers
BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS

Figure 4.5 continued **- GG6 Metals and machinery W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index map by employees and province (below). Italy. 2014-2018**

GG6 W-RR Injuries by province and employed number
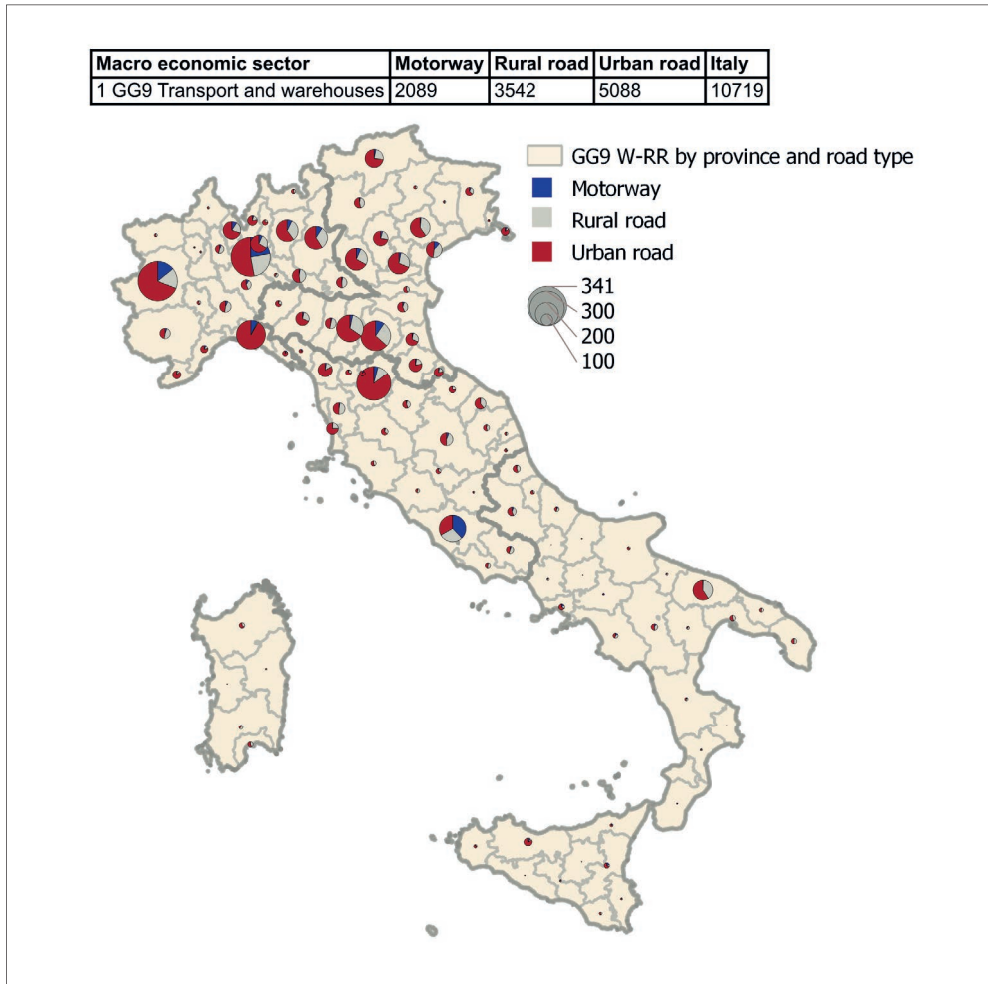- 0,03 - 0,55
- 0,55 - 1,16
- 1,16 - 1,81
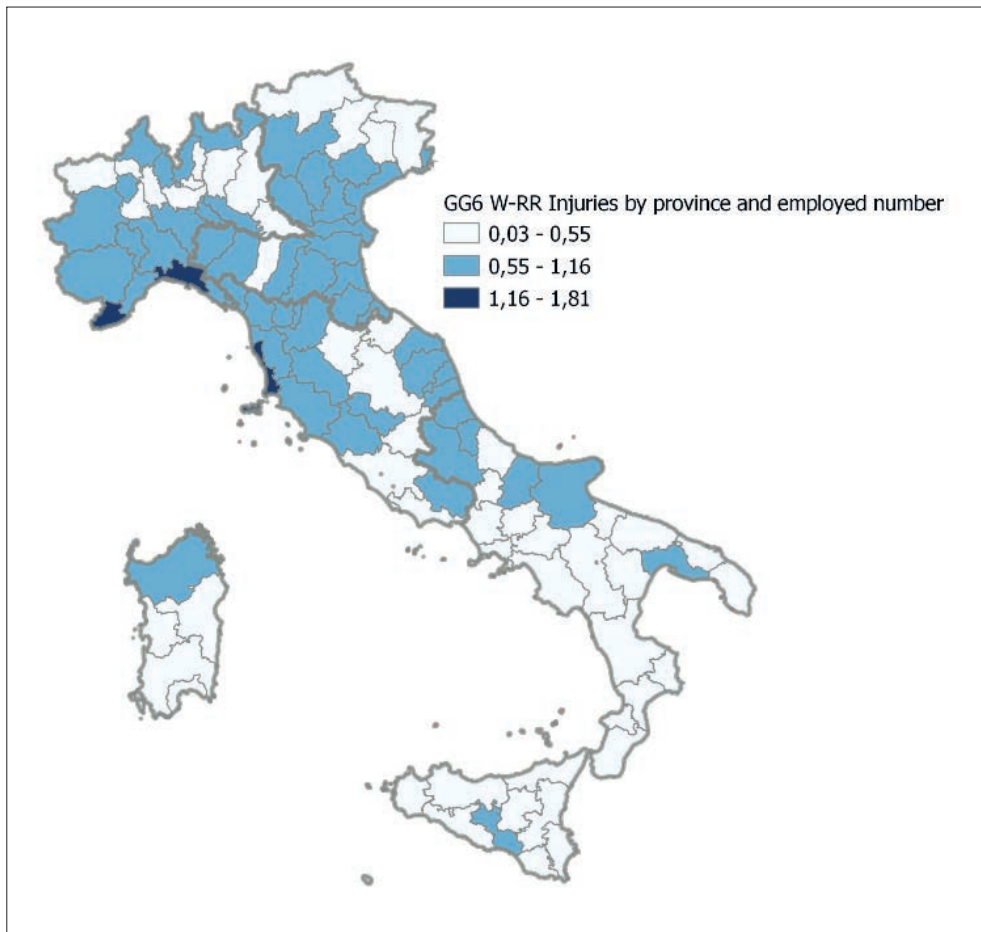
Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS (Jenks)

Figure 4.6 - GG9 Transport and warehouses W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index by employees and province (below). Italy. 2014-2018

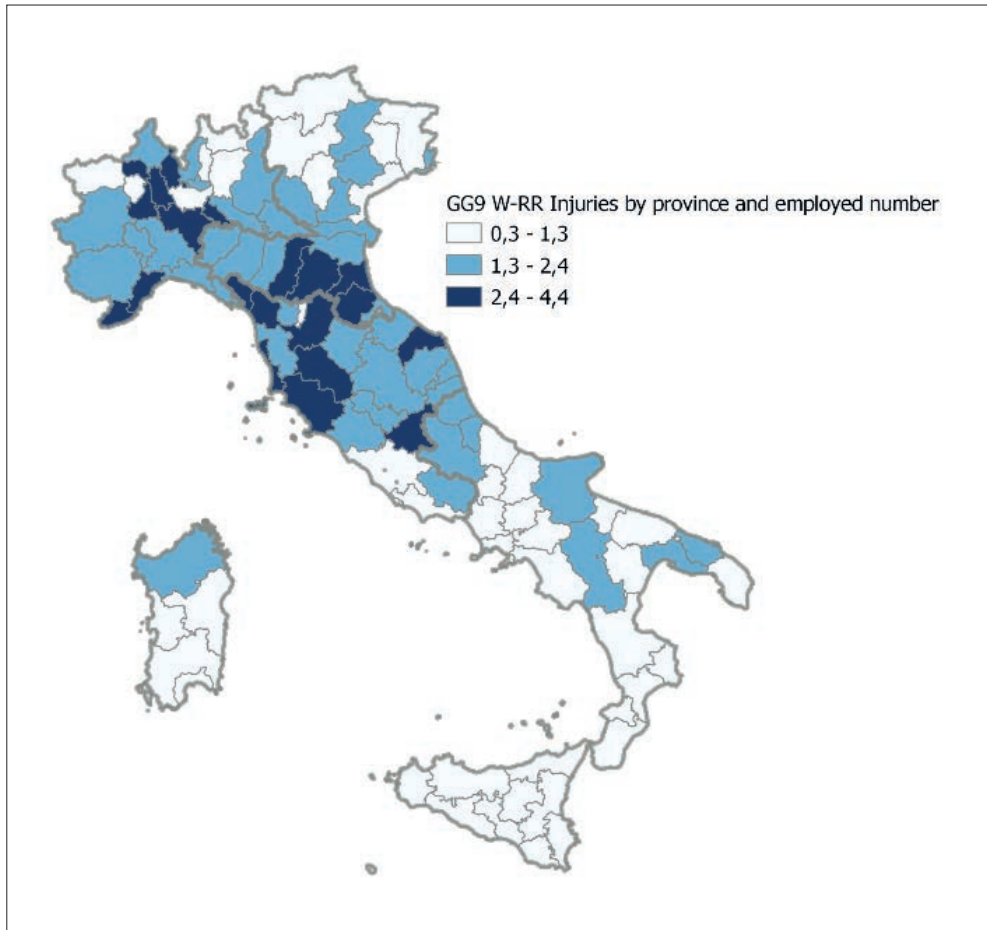| Macro economic sector	Motorway	Rural road	Urban road	Italy
1 GG9 Transport and warehouses	2089	3542	5088	10719

Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS

Figure 4.6 continued **- GG9 Transport and warehouses W-RR injuries. Table and map of absolute values by road type and provinces (bottom) and index by employees and province (below). Italy. 2014-2018**

Source: Authors' processing on integrated Inail - Istat Archives (bottom and below). Inail archives of employed workers BDS Inail, Industry and Services Group, Italy 2018. Updated to 31/10/2020 (below). OpenStreetMap data. QGIS (Jenks)

As reported in Tables 4.1, 4.3 and 4.4, the GG01 sales sector recorded 11,426 injuries and maximum indexes (1.43-2.46) distributed mainly in the North East, North West and Centre (Figure 4.2); the GG6 metals and machinery sector recorded 11,311 injuries and maximum indexes (1.16-1.81), distributed mainly in the North West and Centre along the Tyrrhenian coast (Figure 4.5), while the GG9 transport and warehouse sector recorded 10,719 injuries and maximum indexes (2.40-4.43) distributed mainly in the North West, North East and Centre (Figure 4.6). This was followed by the GG03 health & social services sector that recorded 9,961 injuries and maximum indexes (1.76-3.94), distributed mainly in the North East in the province of Ravenna, in the Centre and in Sardinia (Figure 4.3). On account of its widespread territorial presence, the GG3 construction and plant sector, with 8,212 injuries and maximum indexes (0.80-1.33) distributed mainly in the North East, Centre and to a lesser degree in the North West and South (Figure 4.4) was also included in our observations.

4.2 ANOVA Analysis of variance

ANOVA was performed for two associations: "injuries by road type and territorial division" and "injuries by macro-economic sector (GG) and territorial division". For the former, the p-value (Sig.) was > 0.05 (confidence value limit) for motorways and < 0.05 for rural and urban roads (Table 4.5).

Table 4.5 - ANOVA. W-RR injuries by road type and territorial division (absolute values). Italy. 2014-2018

Road type	Groups or Territorial divisions	Sum of Squares	df	Mean Square	F	Sig.
Motorway	Between Groups	255,433.47	4	63,858.37	1.39	0.242
	Within Groups	4,679,166.76	102	45,874.18		
	Italy	4,934,600.22	106			
Rural road	Between Groups	1,992,042.57	4	498,010.64	7.13	0.000
	Within Groups	7,119,528.09	102	69,799.29		
	Italy	9,111,570.65	106			
Urban road	Between Groups	15,573,684.56	4	3,893,421.14	6.21	0.000
	Within Groups	63,944,958.59	102	626,911.36		
	Italy	79,518,643.16	106			

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018

We failed to reject the null hypothesis for motorways, while it was rejected for rural and urban roads. Variance for rural and urban roads (p-value < 0.05) appears to differ in territorial divisions and vice versa to be homogeneous for motorways (Tables 4.5 and B1 in Appendix B).

Table 4.6 - ANOVA. W-RR injuries by 5 macro-economic sectors and territorial division (absolute values). Italy. 2014-2018

Macro-economic sector	Groups or Territorial divisions	Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	207,210.0	4	51,802.51	5.14	0.001
GG01 Sales	Within Groups	1,027,764.0	102	10,076.12		
	Italy	1,234,974.0	106			
	Between Groups	118,485.8	4	29,621.45	4.38	0.003
GG03 Health social services	Within Groups	690,317.3	102	6,767.82		
	Italy	808,803.1	106			
	Between Groups	123,632.0	4	30,908.00	7.46	0.000
GG3 Construction and plant	Within Groups	422,448.2	102	4,141.65.00		
	Italy	546,080.2	106			
	Between Groups	506,880.0	4	126,720.00	9.72	0.000
GG6 Metals and machinery	Within Groups	1,329,848.0	102	13,037.73		
	Italy	1,836,728.0	106			
	Between Groups	219,388.8	4	54,847.19	4.72	0.002
GG9 Transport and warehouses	Within Groups	1,184,005.0	102	11,607.89		
	Italy	1,403,394.0	106			

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018

For the five macro-economic sectors, the Sig. value resulted less than 0.05 and the null-hypothesis (homogeneity of variances between territorial divisions) was rejected (Table 4.6).

ANOVA performed on indexed frequencies provided overall values of significance < 0.05 (Table 4.7). Consequently, despite the values of significance >0.05 for GG3 construction and plant and GG6 metals and machinery sectors obtained in Table B2 in Appendix B, H_0 was rejected for the five macro-economic sectors analysed. Figure 4.7 illustrates the absolute and relative F values for the 5 macro-economic sectors. As regards absolute frequencies, maximum F values were found for GG6 metals and machinery and minimum values for GG03 health and social services. With regard to indexed frequencies, maximum F values were found for GG3 construction and plant and minimum

values for GG03 health and social services, GG6 metals and machinery and GG9 transport and warehouses. The F values for indexed frequencies were higher than F for absolute values. The only exception was the GG6 metals and machinery macro sector.

Table 4.7 - ANOVA. W-RR injuries. Macro-economic sector and territorial division (relative values), Italy, 2014-2018

Macro-economic sector	Groups or Territorial divisions	Sum of Squares	df	Mean Square	F	Sig.
GG01 Sales	Between Groups	5.50	4	1.38	8.66	0.000
	Within Groups	16.20	102	0.16		
	Italy	21.71	106			
GG03 Health social services	Between Groups	7.87	4	1.97	5.68	0.000
	Within Groups	35.38	102	0.35		
	Italy	43.25	106			
GG3 Construction and plant	Between Groups	2.92	4	0.73	15.70	0.000
	Within Groups	4.74	102	0.05		
	Italy	7.66	106			
GG6 Metals and machinery	Between Groups	1.81	4	0.45	5.89	0.000
	Within Groups	7.83	102	0.08		
	Italy	9.64	106			
GG9 Transport and warehouses	Between Groups	21.81	4	5.45	11.74	0.000
	Within Groups	47.37	102	0.46		
	Italy	69.18	106			

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018. Inail Archives of Employed Workers, BDS Inail. Industry and Services Group. Italy 2018. Updated to 31/10/2020 (see Footnotes 1, 2 and 3)

Figure 4.7 - ANOVA. W-RR injuries by macro-economic sector. Variance ratio between and within divisions (F). Absolute (grey) and relative values (dark grey). Italy. 2014-2018
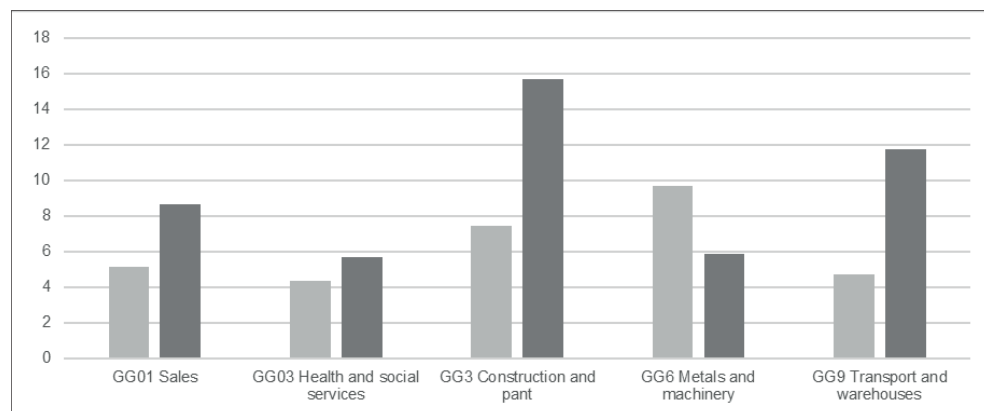
Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018. Inail Archives of Employed Workers, BDS Inail. Industry and Services Group. Italy 2018. Updated to 31/10/2020 (see Footnotes 1, 2 and 3)

5. Discussion

Road accident rates are influenced by many factors such as traffic, road junctions, driving speed and, last but not least, national driving habits and the technical standard of the vehicles used. There is still a lack of knowledge regarding the interaction of the various factors influencing W-RR accident rates (PIARC 2008). Information about accidents and their victims is essential for studying road safety (Hollò *et al.*, 2010), and data concerning W-RR accidents are extremely important since work-related journeys account for a significant part of urban and rural traffic.

Study findings are not consistent between and within Italian territorial divisions for both absolute and relative W-RR injury rates. According to Partyka, simple models of traffic fatalities have been developed using only readily available factors concerning population size and the size of the potential labour force. However, the reader should use caution in interpreting modelling analysis, because the model produces estimates of the effects of variables included in the analysis, but does not imply estimates of the effects of variables omitted in the analysis (Partyka, 1984). According to Hollò, also indicators are unable to provide a full understanding of road safety trends, and, if they are applied generally without the required background information, this may even lead to serious misinterpretation of trends in road casualties (Hollò *et al.*, 2010).

Despite these limitations, the integrated archives on road collisions and injuries, comprehensive of location and economic classification, enabled us to investigate W-RR injuries, nationwide. The descriptive and spatial analysis of the integrated Inail - Istat dataset revealed that the majority of W-RR accidents occurred in the North East, the North West and the Centre (the metropolitan areas of Rome and Florence).

The descriptive analysis of the absolute frequencies of W-RR injuries by road type, macro-economic sector and territorial division (Table 4.1 and Figure 4.1) shows that the urban and rural roads of the North and the Centre are mainly involved in relation to the GG01 sales sector, the GG03 health and social services sector, and the GG6 metals and machinery sector; while in the GG3 construction and plant sector and in the GG9 transport and warehouse sector, both urban and rural roads, and motorways with injury peaks are mainly concentrated in the North and Centre of the country.

Absolute W-RR injury rates by macro-economic sector were highest in the GG01 sales sector, followed by the GG6 metals and machinery sector, the GG9 transport and warehouses sector, the GG03 health and social services sector, the GG3 construction and plant sector, whereas indicators of traffic injuries normalised by the estimated number of workers, were respectively highest in the GG9 transport and warehouses sector, the GG03 health social services sector, the GG01 sales sector, the GG6 metals and machinery sector and the GG3 construction and plant sector (see Tables 4.3, 4.4 and Figures 4.2 - 4.6).

As regards motorways, overall the highest mean was recorded in the North West, while the peak was observed in the Centre (1,556). This last observation confirms the results of a previous study (Brusco *et al.*, 2019) in which the main Rome motorway (the *Grande Raccordo Anulare* - the Ring Road) alone reached the highest accident and injury frequency rate in Italy. On rural roads, the highest peaks and means were recorded in the North of the country, especially in the North East. On urban roads, the means were higher in the North, while the injury peaks (both over 4,200) were in the North West and the Centre (Table 4.2).

Therefore, analysis of macro-economic sector revealed some differences between the absolute (Table 4.3) and indexed rates (Table 4.4). In the GG03 health and social services sector, the indexed values were higher in the Centre and the Islands, while the absolute values were concentrated in the North West. In the GG6 metal and machinery sector, indexed frequencies were highest in the North West and in the Centre, while absolute values were highest in the North. Finally, in the GG9 transport and warehouse sector, the indexed peaks were observed in the Centre and vice versa, the absolute ones were recorded in the North West. A comparison of absolute and indexed data allowed the issue of accidents to be reassessed from a different point of view that took into account also the estimated worker number of each sector (see Table 4.4 and Figures 4.2-4.6).

Indexation using the ratio of two related variables (accident frequencies and the number of employees in each sector) provided a different viewpoint on traffic accidents, useful for expressing a dynamic assessment of how many W-RR injuries "derive" from the total number of workers employed by sector. This information could be useful for analysing W-RR risks by macro-economic sector. The spatial analysis, performed on absolute and

normalised injury rates, did not enable us to identify a common thread in frequency and thereby to reach universally interpretable results for the whole territory. ANOVA pointed out information not available by only the spatial and descriptive analysis.

ANOVA, performed on road type, macro-economic group and territorial division (Tables 4.5 - 4.7 and Appendices) demonstrated that homogeneity of variances between territorial divisions was rejected (except for motorways) and the differences in divisions, hypothesised for the 2014-2018 integrated dataset, were confirmed.

Variances "between" were higher than variances "within" divisions for rural and urban roads, but vice versa for motorways (Table 4.5). A possible explanation of this finding could be the limited number of motorways and the low traffic volume recorded on the same.

As regards the association between macro-economic groups and territorial divisions, the homogeneity of variances between the latter was rejected both for absolute and relative injury rates (Tables 4.6 and 4.7). The highest heterogeneity concerned the macro-economic GG3 construction and plant sector, while the lowest was in the GG03 health and social services sector (absolute and relative). In general, the coefficient F for absolute frequencies was greater than F indexed except in the metals and machinery sector (Figure 4.7). This exception, as well as the results obtained in Table B2 in Appendix B, could be linked to distortion in attributing location as described in Footnotes 1, 2 and 3.

Our study puts forward two sets of hypothetical explanations for the heterogeneity of variances in all the divisions. The first concerns the different structural changes involving organisational, technological and occupational aspects effected in each one that influenced the number of estimated workers (2,537,828 in the North West, 1,854,435 in the North East, 1,432,023 in the Centre, 1,127,507 in the South and 485,740 in the Islands (see Footnote 1 for the 5 economic sector investigated). According to Eksler, structural changes in society and the economy are the most important factor behind trends in road fatalities (Eksler, 2009).

A further explanation concerns the quality of the Inail and Istat dataset, in terms of availability, reliability and completeness of data recorded in each division and included in the integrated Inail - Istat archive data.

A recent survey focussed on the percentage of workers who, in the North West of Italy in the five-year period 2014-2018, used the train or other urban means of transport to get to work. The percentage was much higher than in the remaining divisions (especially those of the South and the Islands). In the North West, rail freight traffic was also higher in the same period than elsewhere (Istat, 2021*b*). These last aspects that diverge from the results of our study may be the cause of differentiation in traffic exposure and accident risk.

A recent study analysed the work-related accident trend in transport and highlighted its critical and peculiar aspects but failed to make any reference to the accident sites or to the indexation by the estimated number of employees (Inail, 2019). Another study referring to the ATECO classification (Istat), analysed indexed W-RR injuries that occurred during the five-year period 2014-2018 in the sales, transport, manufacturing and construction sectors (Pireddu *et al.*, 2021), confirming the highest absolute frequencies in the North and Centre and on urban roads and in the metropolitan area of Rome where, for most of the ATECO sectors, accidents were evenly distributed between motorways, extra-urban and urban roads. According to the ATECO classification, the sales, manufacturing and transport sectors recorded higher indexed injury rates. These differences could be traced back to a different redistribution of accidents and employees in the two classifications (macro-economic sector and ATECO). Variables such as traffic, marginally evaluated by the classification based on the road type (Pireddu and Bruzzone, 2021), driving circumstances (European Commission CARE. 2016) and different driving habits throughout Italy were omitted in our analysis, as well as vehicle devices and technical standards. Despite these limitations, to be further analysed, our study points out essential findings and methods for all those who, with a reactive or proactive approach, are required to analyse road safety and risks in a specific context (Legislative Decree 9 April 2008 n. 81 - *Decreto Legislativo* n. 81/2008 - and Directive 2019/1936/ EU), tariff group and territorial division.

6. Conclusions

The nationwide study investigated injury rates by economic sector, road type and territorial division. The integrated Inail - Istat dataset that included 128,837 accidents resulting in death or injury on Italian roads during the 2014-2018 five-year period, enabled us to analyse occupational and accidental parameters that were not available in the two data archives taken separately.

Absolute and relative W-RR injury frequencies were analysed. ANOVA findings applied to road type showed that injury variances between Italian divisions on rural and urban roads (excluding motorways) were heterogeneous. Variances were also heterogeneous for the macro-economic sector and territorial division (absolute and relative values).

Our study provides essential findings and useful methods for analysing mobility and planning intervention to prevent road accidents with a reactive or proactive approach. The study is also intended for local public authorities responsible for assessing and managing risks in specific contexts.

Appendix A.
W-RR injuries by large tariff group (macro-economic sector) and road type. Italy. 2014-2018

Table A1 - Injury frequencies by macro-economic sector, territorial division and road type (absolute values). All the macro-economic sectors. Italy. 2014-2018

Macro-economic sector and road type		Motorway	Rural road	Urban road
Total	128,837	10,639	37,866	80,332
1 - Industry and services				
1-Service personnel		18	192	1,287
1-GG01 - Sales		879	3,352	7,195
1-GG02 - Reception & Catering		291	2,298	6,577
1-GG03 - Health & social services		567	2,808	6,586
1-GG04 - Cleaning, sanitation and disinfestation		250	1,164	3,532
1-GG05 - Cinematography, culture and sport		102	209	515
1-GG06 - Educational, research and survey		98	427	1,064
1-GG07 - Various undefined activities		3,006	7,207	1,8964
1-GG08 - Undefined activities		191	565	1,186
1-GG1 - Agriculture and food processing		128	1,064	1,630
1-GG2 - Chemical, paper, leather		142	1,049	1,675
1-GG3 - Construction and plant		1,072	2,979	4,161
1-GG4 - Energy and communications		51	221	359
1-GG5 - Wood and the like		47	361	630
1-GG6 - Metals and machinery		701	3,579	7,031
1-GG7 - Mining, minerals and glass		35	283	441
1-GG8 - Textiles and packaging		79	722	1,578
1-GG9 - Transport and warehouses		2,089	3,542	5,088
1-Not classified		465	2,494	4,691
2 - Agriculture				
2 - Agriculture and food processing		101	1,592	1,139
3 - Public administration		303	1,540	3,817
4 - Students		24	218	1,186

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018

Appendix B.
ANOVA. W-RR injuries by macro-economic sector and road type. Italy. 2014-2018

Table B1 - Test of Homogeneity of Variances. Injuries by road type (absolute values). Italy. 2014-2018

Road type	Levene statistic	df1	df2	Sig.
Motorway injuries	2.54	4	102	0.044
Rural road injuries	5.08	4	102	0.001
Urban road injuries	6.60	4	102	0.000

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018

Table B2 - Test of Homogeneity of Variances. Injuries by macro-economic sector (relative values). Italy. 2014-2018

Macro-economic sector	Levene statistic	df1	df2	Sig.
GG01 Sales	4,37	4	102	0,003
GG03 Health social services	9,12	4	102	0.000
GG3 Construction and plant	1.00	4	102	0,412
GG6 Metals and machinery	0,93	4	102	0,450
GG9 Transport and warehouses	6,30	4	102	0.000

Source: Authors' processing on integrated Inail - Istat data. Italy 2014-2018. Inail Archives of Employed Workers, BDS Inail. Industry and Services Group. Italy 2018. Updated to 31/10/2020 (see Footnotes 1, 2 and 3)

References

Brusco, A., A. Bucciarelli, M. Bugani, C. Gariazzo, C. Giliberti, M. Marinaccio, S. Massari, A. Pireddu, L. Veronico, G. Baldassarre, S. Bruzzone, M. Scortichini, M. Stafoggia, e S. Salerno. 2019. *Gli incidenti con mezzo di trasporto. Un'analisi integrata dei determinanti e dei fattori di rischio occupazionali*. Roma, Italy: Inail.

Bruzzone, S., A. Altimari, G. Baldassarre, R. Boscioni, L. Veronico. 2021. "Work-related road accidents: an in depth-statistical analysis carried out by two different integrated data sources". In this issue of the *Rivista di statistica ufficiale*, N. 3/2021. Roma, Italy: Istat.

Cima, V., M. Carroccio, e R. Maseroli. 2014. "Corretto utilizzo dei Sistemi Geodetici di Riferimento all'interno dei software GIS". In *Atti della 18a Conferenza Nazionale ASITA*, 14-16 ottobre 2014, Firenze: 359-363. Milano, Italia: Federazione delle Associazioni Scientifiche per le Informazioni Territoriali e Ambientali - ASITA.

Costabile, S., S. Martini, L. Petriglia, G. Corrarello, e A. Avanzi. 2012. "Geoportale Nazionale. Un approfondimento sulle metodologie di conversione e trasformazione coordinate". *GEOMEDIA*, Volume 16, N. 6: 26-28.

Decreto Legislativo 9 aprile 2008, n. 81 (*Legislative Decree n. 81/2008*). "Attuazione dell'articolo 1 della legge 3 agosto 2007, n. 123, in materia di tutela della salute e della sicurezza nei luoghi di lavoro". Gazzetta Ufficiale della Repubblica Italiana, Serie Generale, n. 101 del 30 aprile 2008, *Supplemento Ordinario* n. 108.

Decreto Legislativo 30 aprile 1992, n. 285 (*Legislative Decree n. 285/1992*). "Testo aggiornato recante il nuovo codice della strada". Gazzetta Ufficiale della Repubblica Italiana, *Serie Generale*, n. 67 del 22 marzo 1994, *Supplemento Ordinario* n. 49.

Directive (EU) 2019/1936 of the European Parliament and of the Council of 23 October 2019 amending Directive 2008/96/EC on *road infrastructure safety management*.

Eksler, V. 2009. "Road Mortality in Europe: A Regional Approach". *Ph.D. Thesis*. Versailles, France: Versailles St-Quentin en Yvelines University.

European Commission, Community Database on Road Accidents - CARE. 2016. "Road Safety: new statistics call for fresh efforts to save lives on EU roads", *Press Release* 31 March 2016. Brussels, Belgium: European Commission.

Gariazzo, C., S. Bruzzone, S. Finardi, M. Scortichini, L. Veronico, e A. Marinaccio. 2021. "Association between extreme ambient temperatures and general indistinct and work-related road crashes. A nationwide study in Italy". *Accident Analysis & Prevention*, Volume 155, 106110.

Glass, G.V., P.D. Peckham, and J.R. Sanders. 1972. "Consequences of non-compliance with the assumptions underlying the analysis of the fixed effects of variance and covariance". *Review of Educational Research*, Volume 42, Issue 3: 237-288.

Harwell, MR., E.N. Rubinstein, W.S. Hayes, and C.C. Olds. 1992. "Summarizing Monte Carlo results in methodological research: The one- and two-factor fixed effects ANOVA cases". *Journal of Educational Statistics*, Volume 17, Issue 4: 315–339.

Hollò, P., V. Eksler, and J. Zukowska. 2010. "Road safety performance indicators and their explanatory value: A critical view based on the experience of Central European countries". *Safety Science*, Volume 48, Issue 9: 1142-1150.

Istituto Nazionale di Statistica - Istat (*Italian National Institute of Statistics - Istat*). 2021*a*.

 "Rilevazione degli incidenti stradali con lesioni a persone". *Informazioni sulla rilevazione*. Roma, Italy: Istat. https://www.istat.it/it/archivio/4609.

Istituto Nazionale di Statistica - Istat (Italian National Institute of Statistics - Istat). 2021*b*. *Indicatori territoriali per le politiche di sviluppo*. Roma, Italy: Istat. https://www.istat.it/it/archivio/16777.

Istituto Nazionale di Statistica - Istat (*Italian National Institute of Statistics - Istat*). 2018. *Annuario Statistico Italiano 2018*. Roma, Italy: Istat. https://www.istat.it/it/archivio/225274.

Istituto Nazionale di Statistica - Istat (*Italian National Institute of Statistics - Istat*). *I.Stat, Your direct access to the Italian Statistics: the complete data warehouse for experts*. Roma, Italy: Istat. http://dati.istat.it/Index.aspx.

Istituto Nazionale di Statistica - Istat (*Italian National Institute of Statistics - Istat*). "Survey on Road accidents resulting in death or injury". In *SIQual - Information system on quality of statistical production processes*. Roma, Italy: Istat. http://siqual.istat.it/SIQual/lang. do?language=UK.

Istituto Nazionale di Statistica - Istat (*Italian National Institute of Statistics - Istat*), e Automobile Club d'Italia - ACI. 2019. "Incidenti stradali in Italia. Anno 2018". Comunicato Stampa. Roma, Italia: Istat. https://www.istat.it/it/archivio/232366.

Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro - Inail (*Italian National Institute for Insurance against Accidents at Work - Inail*). 2019. "Andamento degli infortuni sul lavoro e delle malattie professionali". *Dati Inail*, N. 7/2019. Roma, Italy: Inail. https://www.inail.it/cs/internet/comunicazione/news-ed-eventi/news/news-dati-inail-trasporti-2019.html.

Lix, L.M., J.C. Keselman, and H.J. Keselman. 1996. "Consequences of Assumption Violations Revisited: A Quantitative Review of Alternatives to the One-Way Analysis of Variance F Test". *Review of Educational Research*, Volume 66, Issue 4: 579-619.

Partyka, S.C. 1984. "Simple models of fatality trends using employment and population data". *Accident Analysis & Prevention*, Volume 16, Issue 3: 211-222.

Pireddu, A., A. Altimari, G. Baldassarre, M. Bonafede, R. Boscioni, S. Bruzzone, C. Gariazzo, A. Marinaccio, S. Massari, L. Taiano, T. Tuoto, L. Valentino e L. Veronico. 2021. "Gli infortuni nella classificazione ATECO. Analisi territoriale degli infortuni stradali lavoro-correlati. Potenzialità degli archivi integrati". Poster presentato alla *Quattordicesima Conferenza Nazionale di Statistica "Un moderno ecosistema dei dati per una ripartenza inclusiva e sostenibile"*. 31 Novembre - 1 Dicembre 2021. Roma, Italy: Istat. https://www.istat.it/it/archivio/261537.

Pireddu, A., and S. Bruzzone. 2021. "An analysis of the influence of tunnel length and road type on road accident variables". *Rivista di statistica ufficiale*, N. 2/2021: 71-102. Roma, Italy: Istat. https://www.istat.it/it/archivio/262320.

Taiano, L., S. Massari, T. Tuoto, L. Valentino, S. Bruzzone, and L. Veronico. 2021. "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. Roma, Italy: Istat.