Initial findings on serious injury and long-term consequences

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1. Executive Summary

The injuries of traffic accident victims are well analysed in accident research over the last decades with respect to the injury severity directly after the accident. Little is known however about the long-term consequences of accidents on the physical and psychological status of persons involved in an accident.

This deliverable is produced in the scope of the ProtAct-Us Project with the goal to give an overview of long-term consequences of different types of road users as a result of a traffic accident. In doing so the injuries and where available the long-term consequences were identified using different available statistical and in-depth data sources on road traffic accidents. A special focus was set on the following types of road users: riders of e-scooters in the group of micro e-mobility and bus occupants. In addition to the identification of long-term consequences an overview is given over the predictors which may influence the incidence and the recovery from long-term consequences, as well as an overview of individual and health system expenditure of severely injured patients in three different EU countries: Germany, Greece, and Italy.

Especially for the rather recent appearance of riders of e-scooters in traffic and for bus occupants but also for all the other types of road users the data analysis revealed the need of data on long-term consequences and on individual and health system expenditure.

Keywords: Accident Research, Long-term consequences, Data Analysis

2. Introduction

The objectives of the work package 1 in the ProtAct-Us Project are to produce an assessment concept for long-term consequences and to define relevant use cases of the different types of road users. One task of this process is to review and analyse existing data on serious injuries and long-term consequences (Task 1.1). The results of this task serve as a necessary input for the following tasks on identifying road user baseline use cases as well as the development of a concept for injury mitigation and benefit and are reported in this deliverable.

To achieve this task the indicators of long-term consequences due to physical impairment and also due to cognitive impairment are defined based on the available accident data for the different types of road users. Furthermore predictors for long-term consequences which influence a person's morbidity/quality of life and thus may influence the recovery are identified as influencing factors. Due to the current development and relevance of accidents of riders of micro e-mobility vehicles, such as e-scooters, a special focus is set on this group. Another focus is set on occupants of public transport, i.e. bus occupants. For these groups of road users little to no information is available on long-term consequences thus an analysis of the injury situation is conducted.

In a next step the identification of long-term individual and health system expenditure of traffic accident victims is analysed by type of road user.

The above mentioned analysis is based on statistical accident data from different countries in the EU as well as on in-depth accident data based on the EU-Project REHBIL AID and - where available – on the GERMAN IN DEPTH ACCIDENT STUDY (GIDAS). Further information is gathered by expert opinion and by summarizing known literature on this subject.

3. Identification of physical long-term consequences

The analysis of data concerning long-term consequences in this work package shows the need for further data collection and improved availability. The available data is either based on statistical data, which provide limited details on injuries and their long-term consequences or from the REHABIL-AID project with too few case numbers to identify relevant long-term consequences for all types of road users.

To evaluate the statistical weight of long-term injuries, another approach has been used in France, the Functional Capacity Index (FCI) based on AIS injury descriptions, which is described after the REHABIL study.

3.1 Long-term consequences based on REHABIL AID study

For the identification of severe injuries and long-term consequences, data from the REHABIL-AID project was used. REHABIL-AID was a three-year EU funded project titled "Reducing the harm and the burden of injuries and human loss caused by road traffic crashes and addressing injury demands through effective interventions" which was carried out in Greece, Germany and Italy. The project involved a multicentre longitudinal study aiming to assess the psycho-socio-economic costs of road traffic crashes for severely injured people and identify factors that affect the rehabilitation process, one year after the injury. The study involved collection of data from adult patients, hospitalized in intensive care units of selected hospitals in the three participating countries, with injuries sustained in RTC. The results of the study are meant to be used to develop interventions and tools tailored to the needs of the injured people such as recommendations on the care of the severely injured, a map of rehabilitation services and a map of the care pathway following RTCs.

Study design: Longitudinal, multicenter study of adults who have sustained injuries (admitted to the intensive and sub-intensive care units) in road traffic crashes in Greece, Germany and Italy (2013-2015) [19], [20], [21].

One of the metrics used in the REHABIL-AID project to measure the injury severity is the AIS (Abbreviated injury Scale). The AIS is a scientific evaluation scale for the lethality of individual injuries. The scale has the following characteristics:

- AIS 0 (uninjured)
- AIS 1 (minor injuries, such as abrasions and bruises)
- AIS 2 (moderate injuries, such as broken bones)
- AIS 3 (serious injuries, not life-threatening, e.g. open fractures, amputation of the hand)
- AIS 4 (severe injuries, significantly life-threatening, survival probable, e.g. open skull fracture, amputation of an extremity)
- AIS 5 (critical injuries, survival uncertain, e.g. multiple brain contusion)
- AIS 6 (maximum severity of injury - not treatable, e.g. aortic rupture)

The MAIS (Maximum Abbreviated Injury Scale) describes the maximum injury severity of a patient, i.e. it indicates the AIS value of the most severe single injury of a patient with multiple injuries.

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Using data from the RAHBIL study (n=93 adults), we defined subjects with long-term consequences at one year of follow-up as those having at least one of the following critical values seen in Figure 3–1:

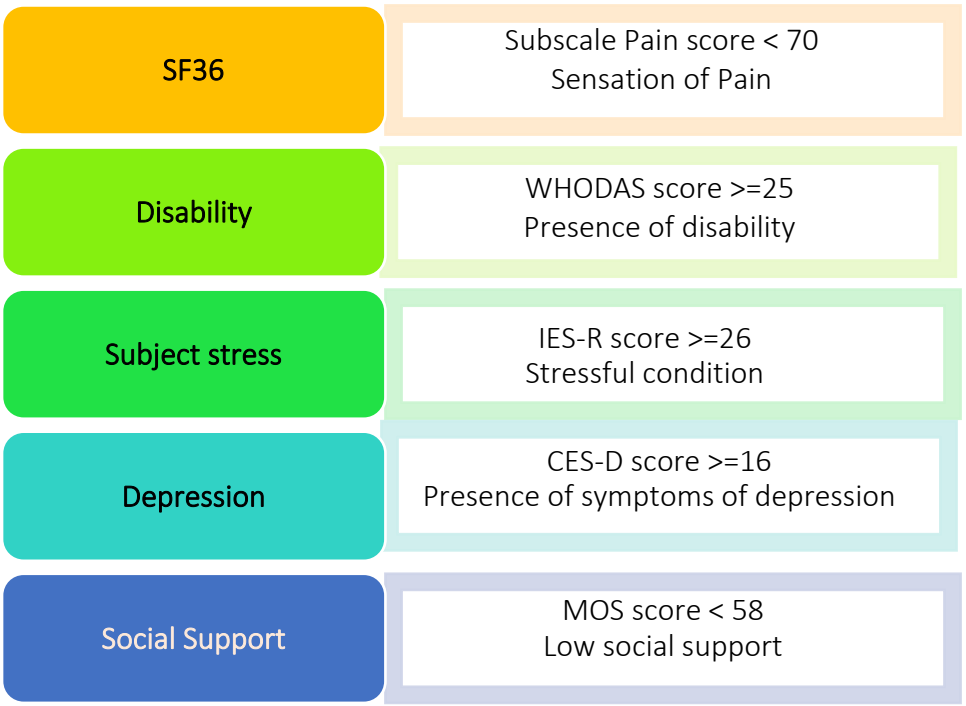


Figure 3–1: Criteria of persons defined as having long-term consequences in the REHABIL-AID Project

At the one-year follow-up inquiry we observed 57 (61%) subjects with long-term consequences and a total of 484 injuries.

The maximum AIS is significantly higher in subjects with long-term consequences than in subjects without long-term consequences (3.0 ±0.9 vs 2.7±0.6, p=0.027). There is no association between injured body area and having or not LTHC (see Table 3-1).

Table 3-1: Injured body region for subjects with and without long-term consequences.

Body area	No LTHC	LTHC	Total
	n=124	n=360	n=484
Face	12 (9.7%)	35 (9.7%)	47 (9.7%)
Head/Brain/Neck	26 (21.0%)	57 (15.8%)	83(17.1%)
Thorax	29 (23.4%)	94 (26.1%)	123 (25.4%)
Abdomen	5(4.0%)	25 (6.9%)	30 (6.2%)
Upper extremities	15 (12.1%)	45 (12.5%)	60 (12.4%)
Low extremities	37 (29.8%)	104 (28.9%)	141 (29.1%)

In Table 3-2 the mean AIS score is displayed for subjects with and without long-term consequences. Among subjects with LTHC, the mean AIS score differs significantly between body areas ($p<0.001$). Specifically, the area with the highest AIS score is the lower extremities (2.36 ± 0.61), followed by the head/brain/neck and thorax (2.30 ± 0.58 and 2.27 ± 0.83, respectively). Similarly, even among subjects without LTHC, the mean AIS at the time of the road accident varies significantly between the body areas involved in the accident ($p<0.001$). In this group, the area with the highest AIS score is the abdomen (4.00 ± 2.8).

Table 3-2: Descriptive statistics of AIS by injured body area by subjects with or without long-term consequences.

Body area	No LTHC	LTHC
	Mean±SD	Mean±SD
Face	1.58±0.52	1.23±0.29
Head/Brain/Neck	2.35±0.61	2.30±0.58
Thorax	2.07±0.72	2.27±0.83
Abdomen	4.00±2.83	2.20±0.55
Upper extremities	2.00±0.54	1.69±0.42
Low extremities	2.05±0.46	2.36±0.61

No significant differences could be identified between the group of persons with long-term consequences and the group of persons without long-term consequences (see Table 3-3)

Table 3-3: Distribution of road users by persons with or without long-term consequences.

Road User	No LTHC	LTHC	Total
	n=36	n=57	n=93
Car occupants	19 (52.8%)	16 (28.1%)	35 (37.6%)
Truck occupants	1 (2.8%)	3 (5.3%)	4 (4.3%)
Riders of PTW	10 (27.8%)	21 (36.8%)	31 (33.3%)
Cyclists	1 (2.8%)	9 (15.8%)	10 (10.8%)
Pedestrian	5 (13.9%)	8 (14.0%)	13 (14.0%)

Using a multivariate logistical model the following results could be identified (Table 3-4):

- Age is associated with the probability of LTHC (OR = 1.05, 95% CI: 1.01–1.09, p = 0.011): for each additional year of age, the probability of LTHC increases by 5%, suggesting older age is associated with a higher risk.
- MAIS is associated with the probability of LTHC (OR = 2.81, 95% CI: 1.32–5.97, p = 0.007): the probability of LTHC is about three times higher for each increase of AIS.
- Riders of powered two-wheelers (PTW) experienced a 5 times higher risk of LTHC than car occupants (OR = 4.66, 95% CI: 1.30–16.77, p = 0.018).
- A potential increased risk of LTHC at intersections than on bends, not statistically significant, is observed (OR = 8.67, 95% CI: 0.77–98.07, p = 0.081).

In summary, older age, riders of PTWs, and injury severity are predictors of LTHC in a multivariate logistic model adjusted by sex.

Table 3-4: Multivariate logistic model.

	Odds Ratio	[95% IC]		p-value
Location				
On bends	1.0			

Intersection	8.67	0.77	98.07	0.081
Straight road	1.43	0.41	4.96	0.572
Parking	1.09	0.12	9.71	0.939
Road User				
Car occupants	1.0			
Truck occupants	4.08	0.29	57.46	0.298
Riders of PTW	4.66	1.30	16.77	0.018
Cyclists	9.19	0.54	155.59	0.124
Pedestrians	1.25	0.29	5.40	0.766
Age	1.05	1.01	1.09	0.011
Max_AIS	2.81	1.32	5.97	0.007

3.2 Long-term consequences based on Functional Capacity Index

In France, the national database named BAAC [1] is post-treated using a detailed database built in the Rhône department, to establish national injury estimations: this methodology is based on the VOIESUR project, which has analysed more than 8000 accidents from 2011, and built a representative and detailed national database, including AIS.

The Rhône database is historically (since 1995) correlated with the national BAAC database and detailed with AIS description. Since AIS 2005, a Functional Capacity Index (FCI) can be calculated, to determine injuries probably responsible for functional impairments one year after accident. The 4 PCI levels are 1 for severe, 2 for grave, 3 for moderated, and 4 for Light.

Based on this methodology, the ONISR can estimate each month the level of Long Term Consequences in terms of functional impairments one year after accident. The results are highly different from fatalities, but also from severe injuries.

In 2023, the FCI repartition was highly different from the transportation mode repartition, calculated with displacement times (Figure 3–2):

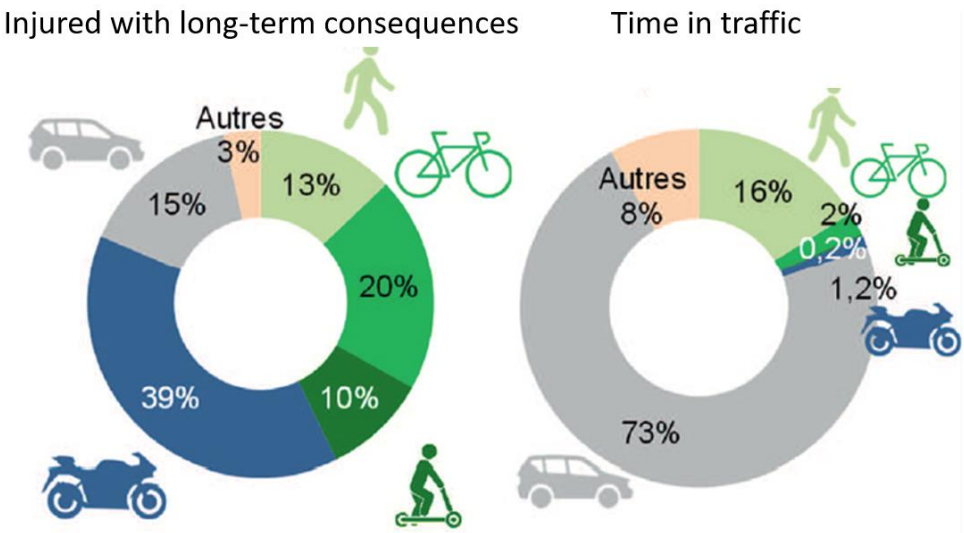


Figure 3–2: Share of mode of transport among injured with long term consequences compared to the respective share of time in traffic.

The cars users have a share of 15% of injured with long term consequences but account for 73% of time in traffic. On the other hand the riders of powered two-wheelers represent 39 % of injured with long term consequences with a share of only 1.2% of traffic participation time. When looking at the riders of e-scooters, the amount of injured with long term consequences, (10%) is much higher than the share of traffic participation (0.1%) Thus the weight of Vulnerable Road Users in traffic is increased by e-scooters.

4. Identification of psychological long-term consequences

There are studies on the relationship between traffic accidents and cognitive impairment, but almost exclusively on cognitive impairment as an influencing factor for the accident (e.g. [7]).

There are few, if any, studies that systematically investigate the relationship between road accidents and long-term cognitive outcomes.

This is particularly surprising as, on the other hand, cognitive impairments have a significant impact on social reintegration and continued employment [8].

However, regardless of the cause of the impairment, two mechanisms/conditional factors for long-term cognitive consequences have been described:

- Traumatic brain injuries - the samples are compiled on the basis of physiological injury and are not specific to road traffic accidents
    - Even mild traumatic brain injuries can lead to cognitive impairment [4], there are few findings on long-term cognitive impairment after mild brain injuries due to road traffic accidents.
    - In the literature, severe brain injuries associated with coma have a higher probability of cognitive impairment [26].
- Psychological stress
    - Psychological disorders such as posttraumatic stress disorder, alcohol dependence, depression and anxiety can appear after accidents and are also characterized by cognitive dysfunctions [17].

Overall, it is likely that already mild traumatic brain injuries due to road traffic accidents can cause long-term cognitive impairments. In addition, it is likely that psychological sequelae due to accidents can also lead to cognitive impairments – with or without brain injuries. However, the specific factors and the extent of the associated cognitive impairments specific to road traffic accidents and specific characteristics of these incidents remain to be identified.

5. Identification of relevant predictors for long-term consequences

In order to assess the relevance of long-term consequences and their occurrence, it is also important to identify factors that influence a person's morbidity/quality of life and thus also recovery. In the scope of a Study for the German Federal Highway Research institute BASt [1] in 2022, a literature study was conducted to gather an overview of identified predictors from other studies. The current list of predictors is based on this study.

For this purpose, the 'PubMed' database [23] was used to search for potential influencing factors (predictors) on the long-term course after a road traffic accident. The search resulted in 195 possible studies from the last 20 years, using the query:

(traffic accident[Title] OR road accident[Title] OR traffic crash [Title] OR trauma[Title]) AND (quality of life[Title]) AND (traffic accident[Title] OR road accident[Title] OR traffic crash[Title] AND (predictor*[Title].

After filtering for relevant abstracts (excluding studies e.g. with reference to a small, specific patient group or to specific, non-trauma-related diseases) and freely available abstracts 20 studies remained as basis for the following summary.

Furthermore, additional predictors that are used in the GIDAS database and predictors identified from the data of the REHABIL-AID project are added [24]. The additional predictors from the GIDAS database are often based on expert opinions collected in dedicated workshops. The predictors identified from the REHABIL-AID project are based on the findings from the second follow-up carried out twelve months after the road accident. Logistic regression analysis shown several significant predictors for the development of physical disability, post-traumatic stress, and depression. The risk of these outcomes was influenced by factors such as injury severity, marital status, and baseline mental health.

For the analysis of these predictors, it is useful to categorize the identified predictors according to the type of predictor as done in the literature review conducted by Alharbi et. al. [1]. The predictors and their effects are divided into the following 6 categories:

- Injury characteristics and treatment-related predictors
- Demographic factors
- Family and social support
- Regulatory processes and accident blame
- Health status before the injury
- Psychological and physical outcome after the accident

The group of 'Injury characteristics and treatment-related predictors' primarily includes accident-related factors such as the injured body part, the severity of the injury, accident resulting in death, perceived danger to life or a longer hospitalization. On the other hand the treatment that is available may have an influence on the long-term outcome. In some countries not all persons may have access to the same treatment. In Germany for example the treatment may differ whether the employers' liability insurance association covers the treatment or if the statutory health insurance covers the treatment (see Table 5-1).

Table 5-1: Injury characteristics and treatment-related predictors

Predictor	Possible effects (examples)	Source
Being a passenger [13]	Poorer psychological outcome expected.	Literature
Relative involved in accident [17]	Poorer quality of life.	Literature
Injury severity [4] Spinal injuries and lower limb injuries [19], [4], [17]	Physical consequences (chronic complication); Poorer social outcome (after 12 months); Poorer psychological outcome (after 12 months).	Literature
Perceived danger to life due to accident. [2] Accident resulting in death. [1]	PTSD (Post-traumatic stress disorder)	Literature
Ankle/foot fractures [11]	Unable to return to work after 12 months	Literature
Whiplash injuries [1]	Deterioration in health-related quality of life (HRQoL) - physical Unsatisfactory state of health; More frequent pain; headaches More frequent psychological stress	Literature
Brain injury [1]	Long-lasting PTSD Post-traumatic stress disorder	Literature
Prolonged hospitalisation [26], [26]	Long-term disability > 6 months	Literature
Healthcare system disparities (differences in access to care, insurance coverage, and socioeconomic factors)	To be further investigated	Expert opinion
Cost unit for healthcare (employers' liability insurance association)	To be further investigated	GIDAS

Demographic and social predictors are in most cases the older age, which has a particularly negative effect on the physical consequences and recovery. However, a low level of education and low social status are also associated with poorer recovery as well as a lack of health literacy. Further factors that may influence the long-term outcome of a trauma is the resilience but possibly also the religiosity of a person. The intention to apply for a pension as a result of the injuries often leads to a poorer recovery. The occurrence and influence of other (psychologic) stressful events since the accident may also influence the recovery (Table 5-2).

Table 5-2: Predictors and their effects from the area of demographic and social factors

Predictor	Possible effects (examples)	Source
Gender (female) [22], [19], [4]	Long-term disability; depression; Increased morbidity	Literature
Older age [4], [28], [4], [13]	Increased morbidity; Poorer physical function and general health; Poorer recovery Depression	Literature REHABIL-AID

Low level of education or social status [22], [13], [13]	Poorer recovery; More frequent psychological consequences.	Literature
Health literacy (the ability to understand and act on health information)	To be further investigated	Expert opinion
Resilience	To be further investigated	GIDAS
Religiosity (Transpersonal trust scale)	To be further investigated	GIDAS
Intention to apply for a pension	Poorer recovery, not yet studied	GIDAS
Other stressful events since the accident (e.g. loss of family member)	To be further investigated	GIDAS

In addition, the patient's family and social support also has an influence on recovery (see Table 5-3). Here, good support from the family or social environment leads to patients feeling healthier, experiencing less pain and reporting a rapid return to optimal function. However, no influence of these predictors on psychological impairment could be identified. The influence of everyday burdens may also influence the recovery but was not yet studied from the GIDAS data.

Table 5-3: Predictors and their effects from the area of Family and social support

Predictor	Possible effects (examples)	Source
Family and social support (spouse, family, friends) [1]	Better physical health; Less pain; Faster return to optimal function; (But: no influence on psychological impairment)	Literature; REHABIL-AID
Functioning and supportive social network [1]	Less frequent development of mental disorders; Help in coping with mental disorders.	Literature
Lack of social support [1]	Poorer recovery	Literature
Everyday burdens	To be further investigated	GIDAS

The literature analysis also shows that bureaucratic processes related to the accident, such as legal disputes and problems with insurance companies, can also have an impact on the long-term outcomes of accident victims. The effects can be psychological, such as stress, worry or post-traumatic stress disorder, but also physical, such as poorer recovery. Self-perceived blame for the accident can also have an influence on recovery. People who feel innocent of the accident are more likely to have psychological and physical problems (see Table 5-4).

Table 5-4: Predictors due to regulatory processes and accident blame

Predictor	Possible effects (examples)	Source
Compensation system: e.g. insurance-related problems such as communication/information problems, rejected payments [1], [4], [26]	Long-term outcomes of: • Stress, • QoL Quality of Life • Worry, anxiety • Depression Poorer recovery;	Literature

	Reduced rate of return to work; More likely to suffer from PTSD Post-traumatic stress disorder	
NOT to blame for the accident (subjective) [1], [14], [15]	Mental/emotional problems; Poorer physical health; Longer time to return to work	Literature

Another important group of predictors of the course of recovery is the state of health before the injury or accident occurred (Table 5-5). Chronic illnesses prior to the accident lead to a reduced health-related quality of life and a lower rate of return to work. However, psychiatric diagnoses prior to the accident can also result in a lower probability of returning to work and increase the probability of post-traumatic stress disorder or depression or worsen the social outcome.

Table 5-5: Predictors due to Health status before the injury

Predictor	Possible effects (examples)	Source
Chronic diseases [13], [26]	QoL after 2 years; Lower return to work after 2 years	Literature
Pre-existing disabilities or degenerative processes (e.g. osteoarthritis)	Poor recovery	Expert opinion
Psychiatric diagnosis [1]	Lower return to work after 2 years	Literature
Depression [14]	More likely to have PTSD (Post-traumatic stress disorder). Depression	Literature REHABIL-AID
Worry, anxiety [1], [14]	Psychological stress Social isolation	Literature
Sleep disorders	To be further investigated	Expert opinion

In addition to the state of health before the accident, the psychological and physical outcome after the accident event also plays an important role in recovery and well-being (Table 5-6). For example, a poorly perceived recovery after the accident increases the likelihood of future anxiety, depression or post-traumatic stress disorder. This in turn can have an influence on the level of pain reported. Further, the type of injuries sustained also has an influence on aftercare and therefore on the number of rehabilitations required. In addition, the visibility of the consequences of an accident (e.g. scars) increases the likelihood of psychological consequences. From the list of predictors from the GIDAS database the return to work status was added as it can be assumed that this may have an influence on long-term consequences

Table 5-6: Predictors due to Psychological and physical outcome after the accident

Predictor	Possible effects (examples)	Source
Poor recovery after the accident [26]	Anxiety; Depression; PTSD Post-traumatic stress disorder; Restrictions in daily living activities; Pain	Literature

Injury severity [4] Depression, worries [1]	Lower return to work after 2 years; Reduced earning potential after the accident	Literature
Injury severity in lower extremities	Physical disability; PTSD (Post-traumatic stress disorder)	REHABIL-AID
Brooding about trauma [1]	PTSD (Post-traumatic stress disorder)	Literature
PTSD (Post-traumatic stress disorder) [14]	Pain intensity	Literature
Brain injury [4]; Injury to the musculoskeletal system, Skin integrity, Pain therapy required [1]	Two or more rehabilitations needed	Literature
Visibility of consequences of the accident (e.g. scars) [1]	Psychological consequences	Literature
Return to work status	To be further investigated	GIDAS

The analysis of the literature in addition with factors from the GIDAS database and the REHABIL AID project as well as expert opinion on the predictors shows that various factors of the person involved in the accident can have an influence on the outcome of the recovery and on the consequences of the accident. Accident-related factors such as specific injuries or perceived danger can increase physical consequences, a poorer social outcome or psychological consequences. However, factors that were already present before the accident, such as advanced age, chronic illnesses or a low level of education, can also have an influence on recovery and well-being. Other predictors can be found in the area of social factors (family and social support) or accident-related official processes that can have an impact on physical and psychological well-being, for example. In addition, both the physical outcome after the accident (e.g. poor recovery, visibility of scars) and the psychological outcome (post-traumatic stress disorder or depression) can influence the course of the long-term consequences. These predictors need to be taken into account when assessing the long-term outcome of injuries. Moreover it also makes sense to survey predictors such as social support at later points in time for those involved with long-term consequences.

6. Accident situation of micro e-mobility road users

One of the subtasks in the scope of reviewing existing injury data in work package 1 is the analysis of the injury consequences of accidents with micro e-mobility such as 'e-scooters'. Due to the fact that these types of road were rarely found in traffic and have only increased in recent years the number of accidents with micro e-mobility is very limited especially in in-depth databases with low case numbers. Therefore, the following analysis of the accident situation is based on statistical accident data from France, Germany and Italy and was conducted by the partner institutions of this work package task. No relevant data could be found in the Greek statistical accident data

6.1 French national statistics (2023)

Since the pandemic, the proportion of vulnerable road users (pedestrians, cyclists, e-scooterists, motorised two-wheelers) among those killed or seriously injured has increased. In 2023, 1,512 occupants of passenger vehicles were killed, 706 users of powered two-wheelers, 439 pedestrians, 221 cyclists and 44 e-scooterists.

Car occupants now account for less than half of those killed (48%). The proportion of motorised two-wheeler users remains stable: they account for 22% of those killed, 34% of those seriously injured and 38% of those injured who will suffer after-effects 1 year after the accident, for less than 2% of motorised traffic. The proportion of cyclists and e-scooterists is increasing, they account for 8% of fatalities, 20% of those seriously injured and 30% of those injured with permanent injuries 1 year after the accident.

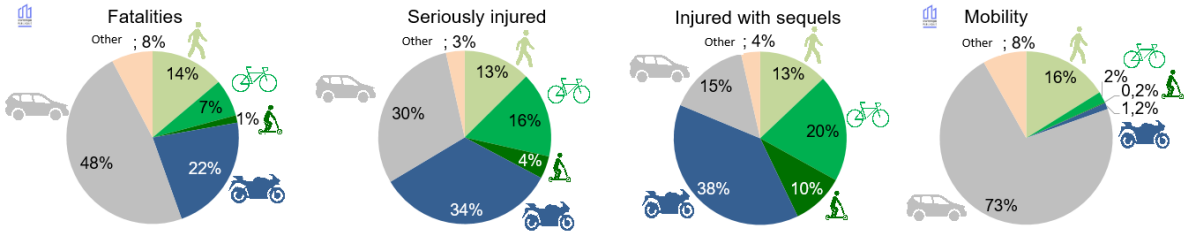


Figure 6–1: Shares of different groups of road users among fatalities, injuries and mobility. Source: ONISR definitive data up to 2023. Data relating to injury accidents recorded by the police, mainland France

French accident situation of vulnerable road users:

The estimated number of seriously injured cyclists is higher in urban areas, particularly for those aged 25-54; the number of cyclists killed is higher outside urban areas, especially for those aged 55 and older, whose mortality increased in 2023 with 96 deaths, which is 30 more than in 2019.

In 2023, there were 44 e-mobility users killed (34 more than in 2019), and the estimated number of injured (three-quarters in urban areas) increased from 158 to 671 in the same period, which is four times more. It is estimated that there are three times as many seriously injured cyclists as seriously injured e-scooter users. Furthermore, the number of seriously injured e-mobility users outside urban areas has increased tenfold since 2019, even though this mode of transportation is generally not permitted there.

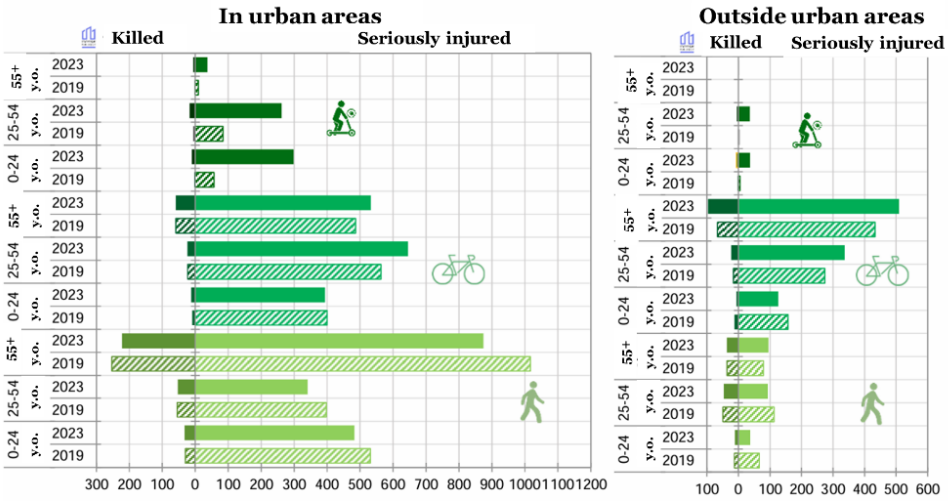


Figure 6–2: Comparing fatally and seriously injured different types of road users from the year 2019 to 2023. Source: ONISR final data up to 2023

44 users of motorized personal mobility devices (e-mobility) died in 2023 (33 in urban areas and 11 outside urban areas), with around 700 seriously injured. Two-thirds of those killed using e-mobility were between the ages of 18 and 44. The estimated number of serious injuries among e-mobility users has been steadily increasing since 2019 (Figure 6–2). This increase accelerated in early 2021 and continued through 2023 with 671 estimated seriously injured (MAIS3+). The rise is mainly observed in urban areas; however, the increase outside urban areas, which intensified in 2022, stabilized during 2023.

The 44 people died by using e-mobility account for 1% of road fatalities and 4% of serious injuries. It is estimated that this year, 2023, 17,508 people were injured while using an e-mobility, with 650 of them suffering serious injuries, marking a moderate increase compared to 2022 (+5%). For the first time in 2023, sales of new electric scooters declined in France compared to 2022 (-11%). In 86% of bodily injury accidents recorded by law enforcement involving an e-scooter, the victim is the e-mobility user. Two moped riders were killed in collisions with an e-scooter. Among the 103 e-mobility fatalities from 2021 to 2023, 4 were in electric wheelchairs.

Among the 103 e-mobility users killed between 2021 and 2023, 41 were in collisions with cars, and 28 died in accidents involving no other parties. In fatal accidents with third parties, the e-mobility was traveling without any trajectory in 40% of cases and crossing the roadway in 20% of cases. According to the Rhône hospital victim registry, 70% of e-mobility injuries occur during a fall without third parties or obstacles. These accidents have the same level of severity as other e-mobility accidents.

6.2 German national statistics (2023)

The German national statistics on accidents with e-scooters mostly reflect the French situation. The number of traffic accident victims is increasing. In 2023, the police registered a total of 9,425 e-scooter accidents with personal injury in Germany - 14.1% more than in the previous year (8,260 accidents). A total of 22 people lost their lives in those accidents in 2023 – more than double compared to the previous year 2022 [6]. Of these 22 fatalities 21 were on behalf of the e-scooter riders which accounts for less than 1% of all traffic fatalities in Germany and

the 1,084 severely injured e-scooter riders account for 2% of all severely injured traffic participants in the year 2023 (Table 6-1).

Table 6-1: Share of fatally and severely injured of e-scooter riders compared to car occupants and cyclists in Germany, years 2022 and 2023 (Severely injured = 24h in hospital).

Type of Road User	Fatalities 2022	Fatalities 2023	Severely injured 2022	Severely injured 2023
Car occupants	1,192	1,192	22,288	20,389
Cyclists	474	446	16,041	14,464
Micro e-mobility (e-scooters)	**10 (0.4%)**	**21 (0.7%)**	**1,099 (1.9%)**	**1,084 (2.0%)**
Others	1,112	1,180	18,299	16,965
Total	2,788	2,839	57,727	52,902

However overall, e-scooters play a comparatively minor role in accidents: in 2023, the police registered a total of 291,890 accidents with personal injury, with only 3.2% involving an e-scooter rider. In 2022, the proportion was slightly lower at 2.9%.

As in France, the age profile of the e-scooter riders is clearly younger than with other types of road users. As reported by the Federal Statistical Office (Destatis):

- 41.6% of e-scooter riders involved in accidents in 2023 were younger than 25 years,
- 80.4% were younger than 45 years.

As a comparison: The Riders of bicycles or Pedelecs involved in accidents were younger than 25 years in 22.1% of cases and were younger than 45 years in 48.7% of cases.

In 66.3% of the e-scooter accidents with casualties were caused by the riders of the e-scooters. The most common misbehaviour, with a share of 19.4%, was incorrect use of the carriageway or footpaths. The police charged e-scooter drivers with driving under the influence of alcohol comparatively often at 15.1% of cases in 2023. In comparison: In the same period, the figure for cyclists was 8.1 %. In that year 3,189 (33.8%) of e-scooter accidents involving personal injury were single-vehicle accidents, meaning there was no other parties involved in the accident. A second road user was involved in almost two thirds (6,115) of e-scooter accidents involving personal injury; in most cases, this was a driver of a car (3,930 accidents). Just under half (48.0 %) of the e-scooter users involved in accidents were injured in such collisions with cars.

6.3 Italian national statistics (2022)

At the time of the analysis, Italian statistical data on accidents was only available for the year 2022 the latest.

As in France and Germany the share of e-scooters (e-micro mobility) involved in traffic accidents in Italy is rather small with 1.3%, according to ISTAT. Among these e-scooters had a share of 1.7% of all injured traffic participants in Italy (see Table 6-2) and a share of 1.2% of all traffic-fatalities (Table 6-3).

Table 6-2: Share and number of injured people by type of road user and gender in Italy in 2022 (source ISTAT).

Road users injured in RTC	Injured %	Total	M %	F%	M	F
Four-wheelers	57.0	127,418	51.74	66.77	75,065	52,353

Cyclists	7.0	15,598	7.84	5.39	11,371	4,227
E-micro mobility	**1.7**	**3864**	**2.04**	**1.15**	**2,966**	**898**
Motorized two-wheelers	24.9	55,532	31.35	12.83	45,475	10,057
Pedestrians	8.5	2,001	0.80	1.08	1,158	843
Other	0.9	19,062	6.23	12.79	9,036	10,026
Total	100	223,475	100	100	145,071	78,404

Table 6-3: Share and number of fatally injured people by type of road user and gender in Italy in 2022 (source ISTAT).

Fatalities of road users in RTC	Injured %	Total	M %	F%	M	F
Four-wheelers	50.0	1,563	48.20	55.17	1,243	320
Cyclists	5.9	185	6.09	4.83	157	28
E-micro mobility	**1.2**	**36**	**1.20**	**0.86**	**31**	**5**
Motorized two-wheelers	27.5	859	30.94	10.52	798	61
Pedestrians	15.5	485	12.60	27.59	325	160
Other	1.0	31	0.97	1.03	25	6
Total	100	3,159	100.00	100.00	2,579	580

Furthermore, the Italian figures show that males are predominant 3.3 fold among those riders of e-scooters that were injured (male: 2,966 vs female: 898) as well as 6 fold among those riders of e-scooters that were killed (male: 31 vs female: 5).

Italy also has a high number of young riders among those that were injured: 32.1% were in the age group of 24 years or younger and 76% were in the age group of 44 years or younger.

In summary the data show that the share of e-scooters in accidents is rather low compared to other types of road users. However it can be seen that young riders are overrepresented: A large proportion of those involved in e-scooter accidents are young and male. The most common causes of accidents include inappropriate speed, driver error, drink driving and distraction. Many accidents occur in urban areas, at junctions. Typical injuries in e-scooter accidents are bruises, broken bones and head injuries.

7. Accident situation of bus occupants

ZF Friedrichshafen AG conducted a GIDAS accident analysis for the road user group shuttles and busses (M2/M3) for the years 2010 to 2024. Therefore, reconstructed accidents in the German cities Hannover and Dresden are analysed with focus on injury severity and likely long term consequences. As accident type collisions between shuttles and busses with all other road users and objects are considered as well as harsh braking situations without collisions. Under these boundary conditions in total 219 accident cases are available in which 402 passengers are injured and 34 persons are with likely long term consequences.

Figure 7–1 shows the age and gender of the injured bus and shuttles passengers. Nearly one third of the involved persons are male and two thirds are female. The age is from 0 years up to 91 years with peaks at the age group 11 to 15 years, 51 to 55 years and 76 to 85 years.

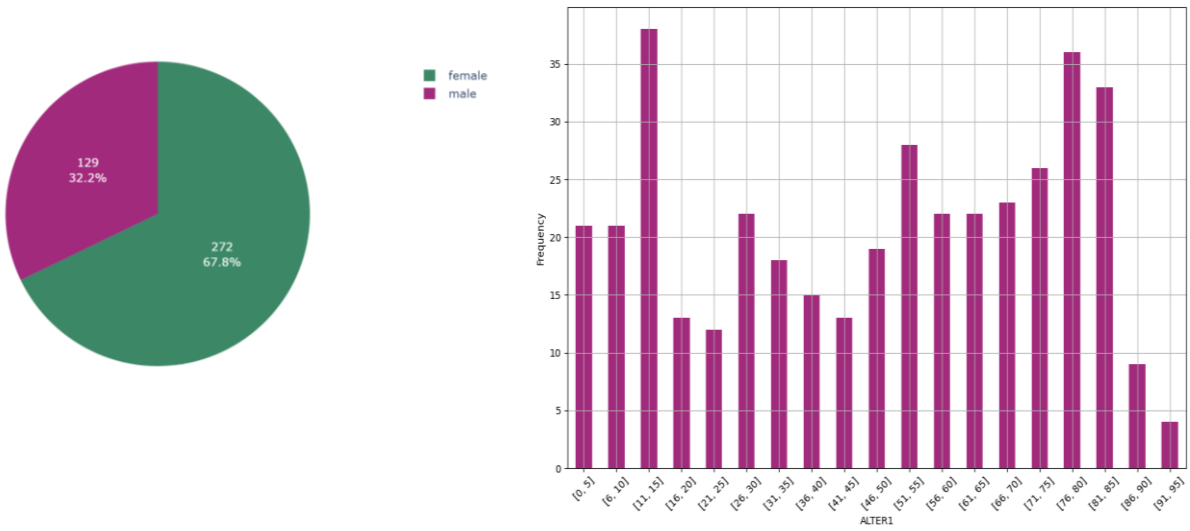


Figure 7–1: Gender and age of injured bus and shuttle passengers

The accidents usually occur in urban areas at crossings, junctions or on straights where for example passengers are injured due to an emergency braking manoeuvre (Figure 7–2).

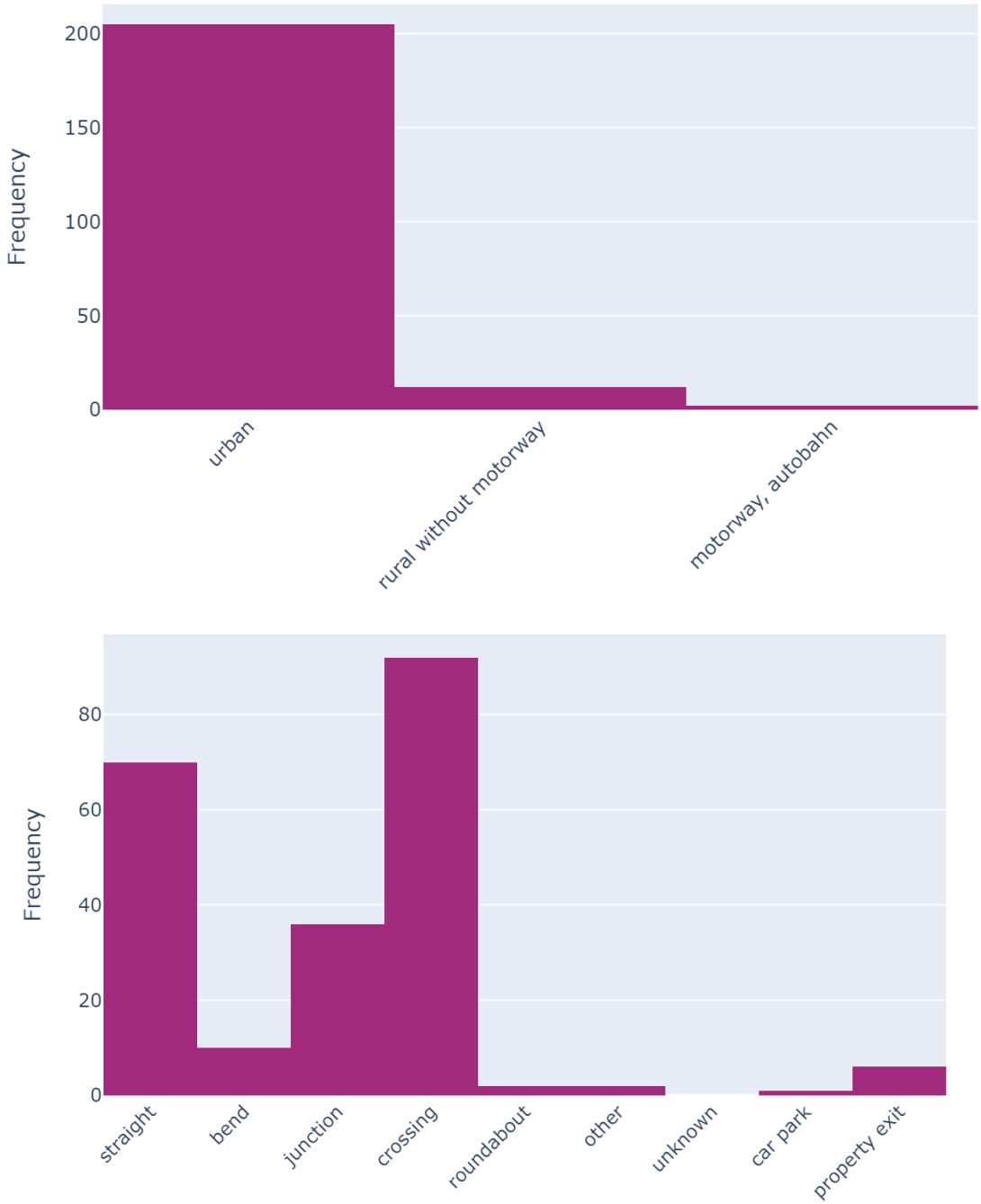


Figure 7–2: Accident site and accident location in the road network of bus and shuttle collisions

Figure 7–3 shows the relationship between accidents with and without other road users. 69 % of the accidents are braking situations. For the accidents with other road users the collision partners are mostly passenger cars followed by HGV, pedestrians and bicycles.

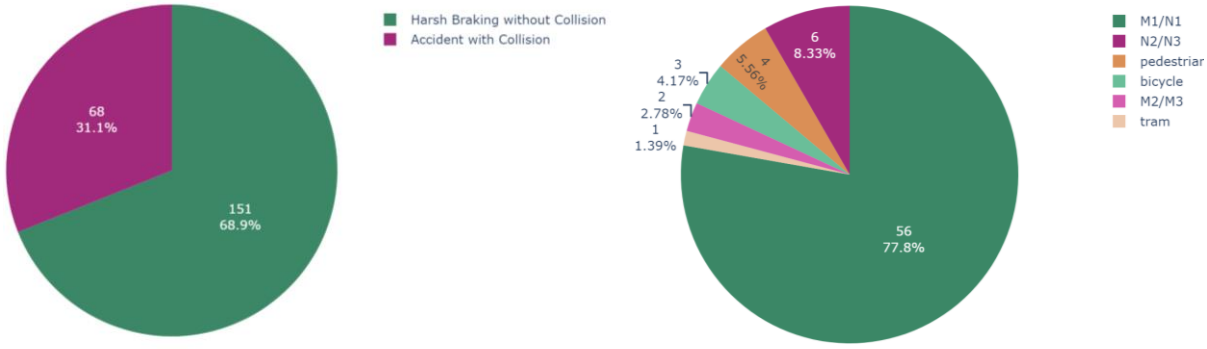


Figure 7–3: Accident type and type of bus and shuttle collision traffic partners

The relative speed between the two collision partners as well as the collision direction is shown in Figure 7–4. The speed range is from 0 to 115 km/h. The accidents occur frequently at speeds between 15 and 30 km/h and at 40 km/h. The main collision direction is frontal followed by side left.

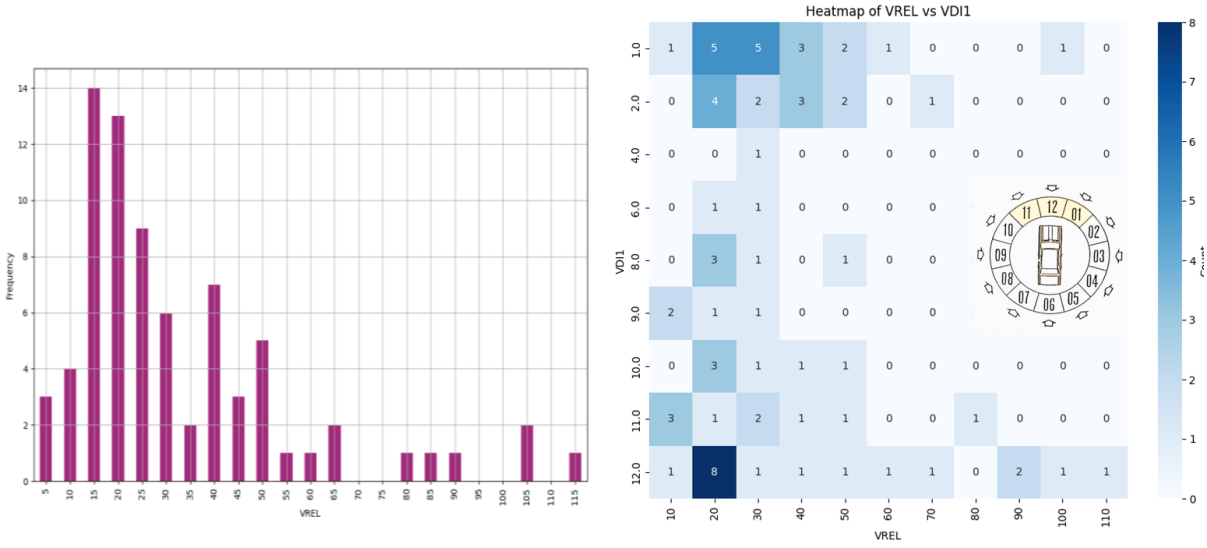


Figure 7–4: Relative speed and impact direction of bus and shuttle collisions with other road users

The maximum injury severity is shown in Figure 7–5 and the injury severity at the available body region is shown in Figure 7–6. There are only 9 passengers seriously injured (MAIS3+). The body regions with the highest share of injuries are lower extremities and thorax followed by abdomen, head and pelvis.

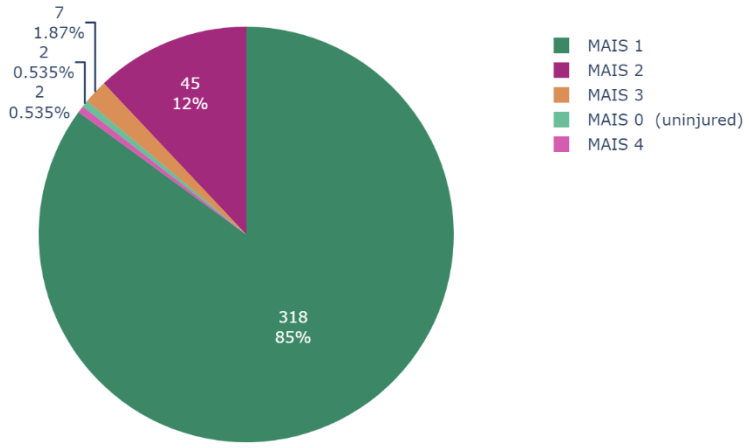
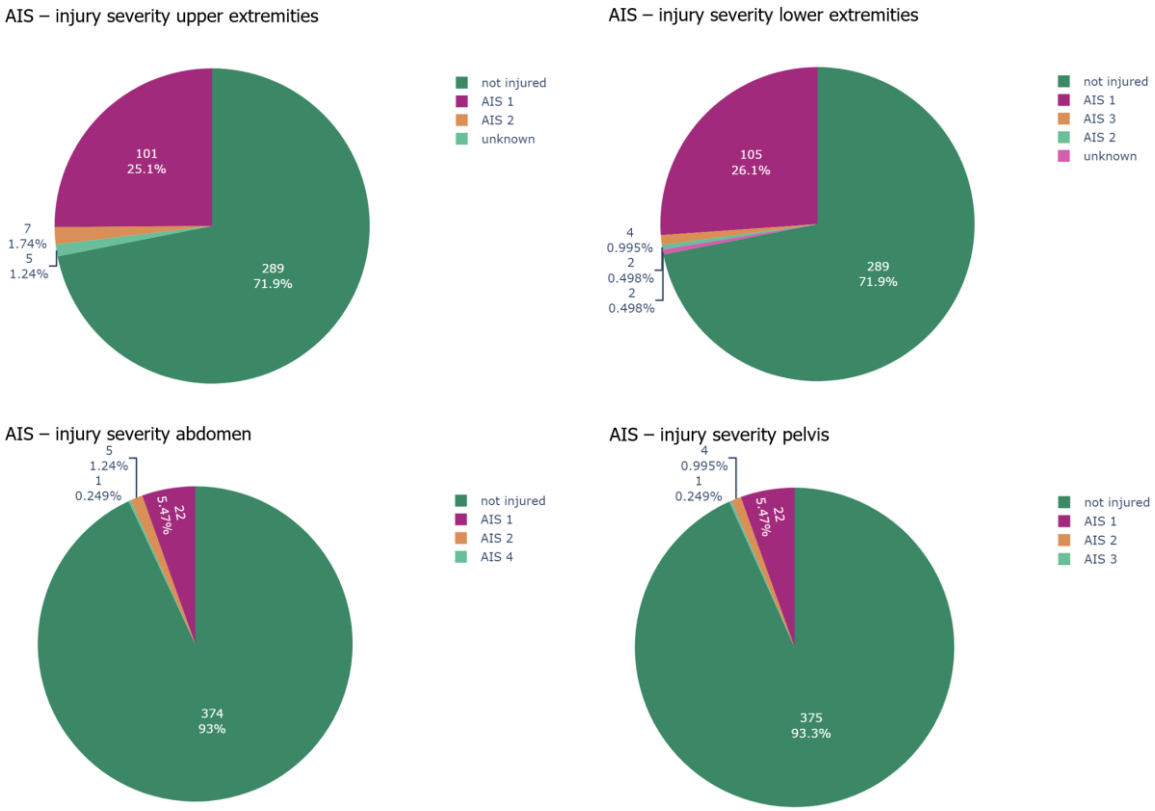


Figure 7–5: MAIS of injured bus and shuttle passengers



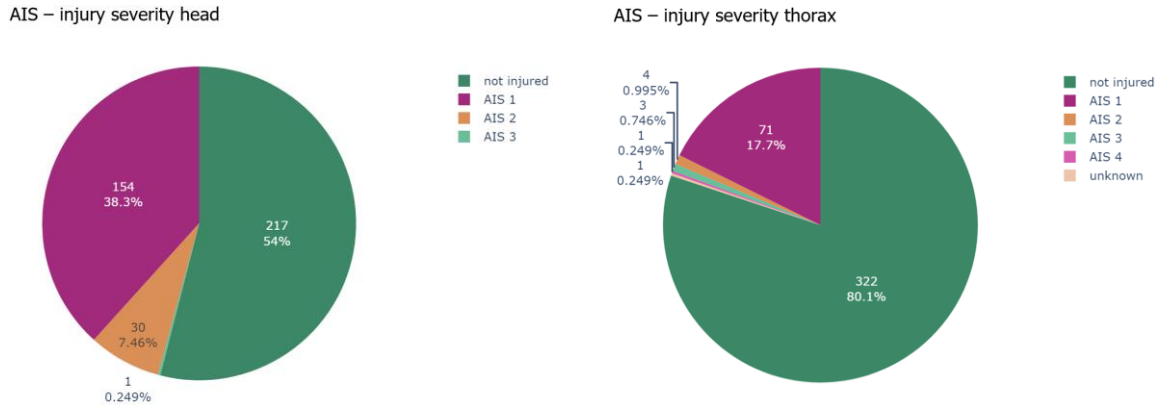


Figure 7–6: AIS of different body regions for injured bus and shuttle passengers

In the GIDAS database there are also information about long term consequences available (Figure 7–7). This information is entered directly at the time of the first treatment and corresponds to the long term effects that will likely appear. The main foreseen LTC for bus and shuttle passengers are pain, mobility restrictions and psychological problems.

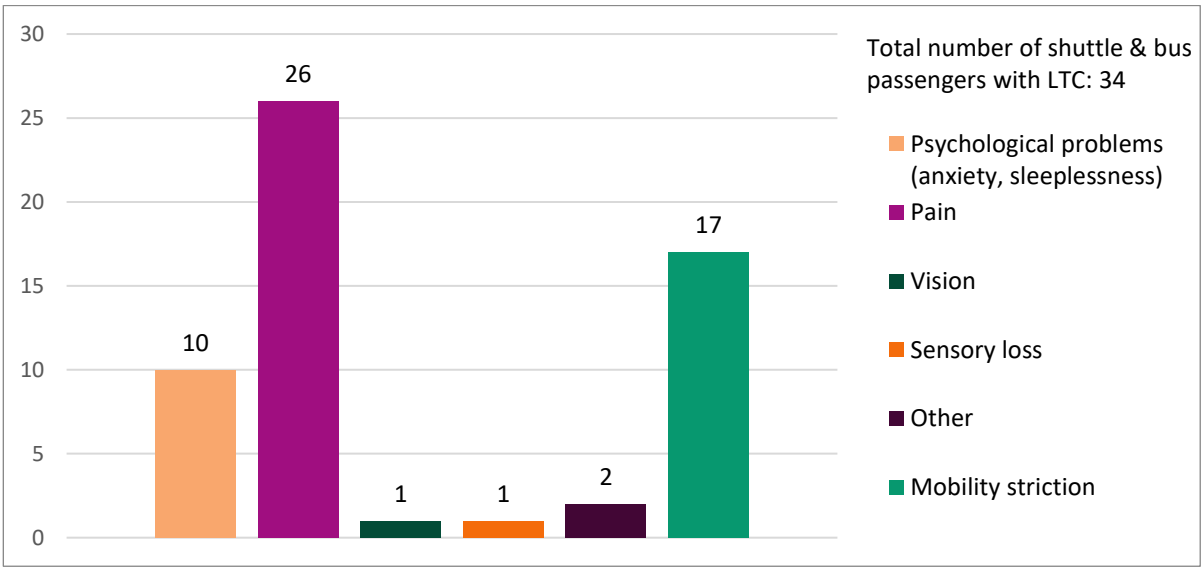


Figure 7–7: Entered likely long-term effects identified during first treatment of bus and shuttle passengers

Summarized, the number of GIDAS bus and shuttle accidents between 2010 and 2024 is with 219 cases low. The passengers are often injured due to harsh braking situations or collisions with passenger cars in urban areas at junctions, crossings or longitudinal traffic. There are only a few cases with seriously injured passengers (MAIS3+) as well as foreseen long term consequences at the time of the first treatment. The body regions of the serious injuries are lower extremities, thorax, abdomen, head and pelvis. The main likely long term consequences are pain, mobility restrictions and psychological problems.

8. Identification of long-term individual and health system expenditure

For the analysis of individual and health system expenditure, the cases collected by the REHABIL AID project were used. The analysis is separated for direct costs and indirect costs.

Direct Costs: Costs relating to the treatment of injury such as inpatient and outpatient hospital costs (e.g. number of admissions/visits, length of staying, reason of admission/visit, means of transport and approximate mileage, transport fare, insurance coverage, etc.) as well as paid carers' costs (e.g. weekly hours of in-hospital care by paid carers, cost of paid carers, etc.), ambulance transport, prescribed and nonprescribed medication (generic name, course and cost of medication, insurance coverage, etc.), equipment (e.g. cost of wheelchair), medical tests (e.g. cost of x-rays or blood tests), and treatment by health professionals other than medical doctors (number and cost per visit to physicians of various specialties, nursing services, social services, etc.).

Indirect Costs: Costs relating to the loss, or partial loss, to society of the productive efforts (both paid and unpaid) of injury victims and care-givers in the case of children (e.g. changes in employment status of the injured person or a family member such as loss of employment or changes in position and salary, childcare arrangements such as change of school or need for paid child-caregiver, in-house adaptations such as ramp or stair lift or moving to a different house, etc.). In addition to the above, the questionnaire explored the participant's governmental benefits and allowances due to disability.

8.1 Profile of REHABIL-AID sample

A total of 120 patients enrolled in the study in all the partner countries (GR=41, DE=39, IT=40). Most individuals in the three countries were men, employed, with low income and high level of education. Germany recorded the highest percentage of employed individuals, Greece the highest percentage of unemployed and Italy the highest percentage of retired. Most of the Greek individuals reported an income of up to €15,000, while half of the German and nearly half of the Italian reported an income of €15,001–28,000.

Table 8--1: Socioeconomic profile of injured individuals admitted to ICU by country.

	Greece		Germany		Italy		Total	
Gender	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Men	36	87.8	27	69.2	30	75.0	93	77.5
Women	5	12.2	12	30.8	10	25.0	27	22.5
Age*	35.9 (SD15.9)		42.7 (SD16.4)		47.0 (SD16.4)		41.8 (SD16.7)	
Education	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Low	33	80.5	2	5.1	12	30.0	47	39.2
High	8	19.5	30	76.9	21	52.5	59	49.2
Higher	0	-	7	18.0	7	17.5	14	11.8
Profession	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Unemployed	8	19.5	1	2.6	2	5.0	11	9.2
Employed	17	41.5	29	74.4	19	47.5	65	54.2
Self-employed	8	19.5	1	2.6	5	12.5	14	11.7
Retired	3	7.3	5	12.8	9	22.5	17	14.1
Other	5	12.2	3	7.7	5	12.5	13	10.8
Income	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
< 15,000	33	86.0	2	5.1	10	30.3	45	40.9
15,001–28,000	5	13.2	20	51.3	14	42.4	39	35.5
28,001–55,000	0	-	16	41.0	3	9.1	19	17.3
55,001–75,000	0	-	0	-	4	12.1	4	3.6
>75,000	0	-	1	2.6	2	6.1	3	2.7

**mean, standard deviation*

In Greece most individuals were motorcyclists (47.6%), while in Germany they were four-wheel drivers (41.0%). In Italy a similar percentage of cyclists (25.0%), four-wheel drivers (25.0%), and motorcyclists (20.0%) was recorded. Collisions in all the countries involved a car (see Table 8--2).

Table 8--2: Road incident information by country.

	Greece		*Germany*		*Italy*		*Total*	
Type of road user	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Pedestrian	2	4.9	5	12.8	7	17.5	14	11.7
Cyclist	1	2.4	3	7.7	10	25.0	14	11.7
Motorcyclist	20	48.8	12	30.8	8	20.0	40	33.3
Driver four-wheel	14	34.1	16	41.0	10	25.0	40	33.3
Passenger four-wheel	4	9.8	3	7.7	5	12.5	12	10.0
Road crash Involvement	17	41.5	11	28.2	15	37.5	43	35.8
Partner in collision	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Motorcyclist	1	2.5	1	2.6	0	-	2	1.7
Car	15	37.5	16	41.0	20	50.0	51	42.9
Truck-bus	3	7.5	9	23.1	6	15.0	15	15.1
Fixed object	3	7.5	7	17.9	3	7.5	13	10.9
Other	11	27.5	4	10.3	11	27.5	26	21.9
Unknown	7	17.5	2	5.1	0	-	9	7.6

Concerning the injury-related characteristics a total of 83 cases (69.1%) were classified as "MAIS 3+". Germany recorded more "MAIS 3+" individuals and Italy more "MAIS1-2". In Greece most individuals sustained a head injury, in Germany a thoracic injury and in Italy an injury in low extremities. "MAIS 3+" individuals in the three countries primarily sustained an injury at the lower extremities (n=53) and thorax (n=51), see Table 8-3

Table 8-3: Injury related information by country.

	Greece		Germany		Italy		Total	
Injury severity *(MAIS score)*	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1 (Minor)	2	4.9	0	-	0	-	2	1.7
2 (Moderate)	11	26.8	6	15.4	17	42.5	34	28.3
3 (Serious)	25	61.0	22	56.4	13	32.5	60	50.0
4 (Severe)	0	-	5	12.8	10	25.0	15	12.5
5 (Critical)	1	2.4	6	15.4	0	-	7	5.8
6 (Maximum)	1	2.4	0	-	0	-	1	0.8
9 (Not specified)	1	2.4	0	-	0	-	1	0.8
Injury location	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Head	25	61.0	7	18.0	9	22.5	41	34.2
Face	1	2.4	3	7.7	2	5.0	6	5.0
Thorax	7	17.1	23	59.0	5	12.5	35	29.2
Abdomen	6	14.6	4	10.3	1	2.5	11	9.2
Spine	2	4.9	3	7.7	7	17.5	12	10.0
Lower extremities	10	24.4	15	38.5	19	47.5	44	36.7
Upper extremities	3	7.3	1	2.6	4	10.0	8	6.7

The analysis of the socioeconomic differences in injury severity show the following: as regards to age differences, while the mean age of MAIS1, 2 and MAIS3+ individuals were similar, Italy recorded the highest average age among "MAIS 3+" cases with a mean age of 48.3 years (Figure 8–1).

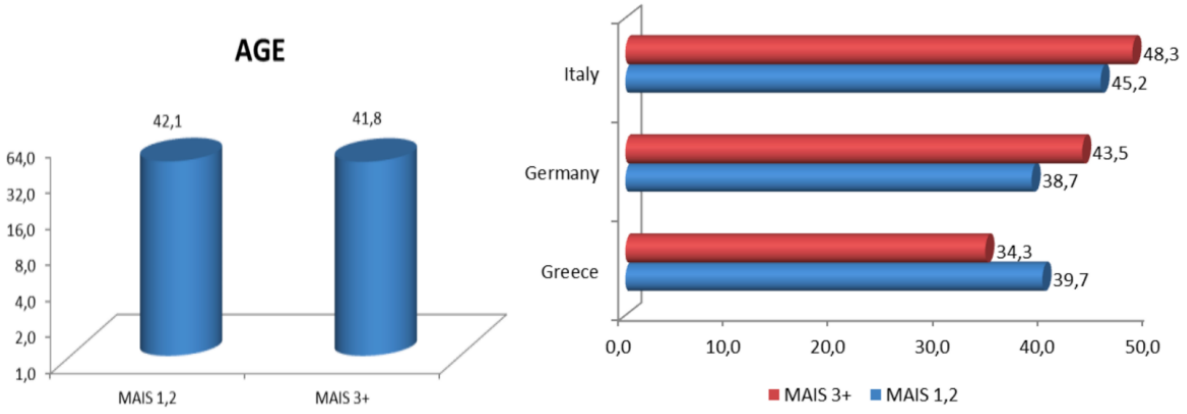


Figure 8–1: Age Distribution of MAIS cases and by country.

Looking at the educational level, graduates of technical school were overrepresented among "MAIS 3+" individuals. Looking at country differences, most "MAIS 3+" individuals in Greece were illiterate (n=14), while most "MAIS 3+" individuals in Germany and Italy were graduates of technical school (n=19 and n=13, respectively)

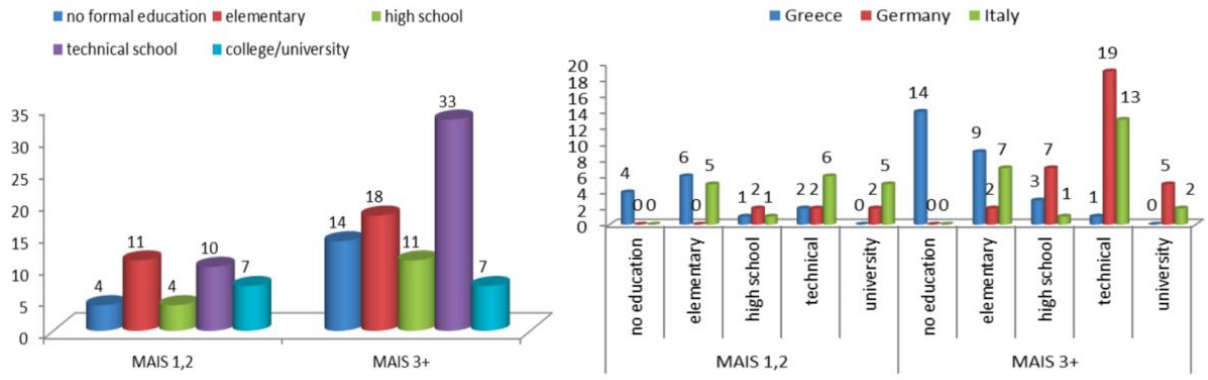


Figure 8–2: Educational levels among MAIS individuals and by country.

As for the occupation, salaried individuals were overrepresented in both injury severity categories. In Greece, MAIS3+ cases involved a large percentage of unemployed and in Italy a large percentage of retired.

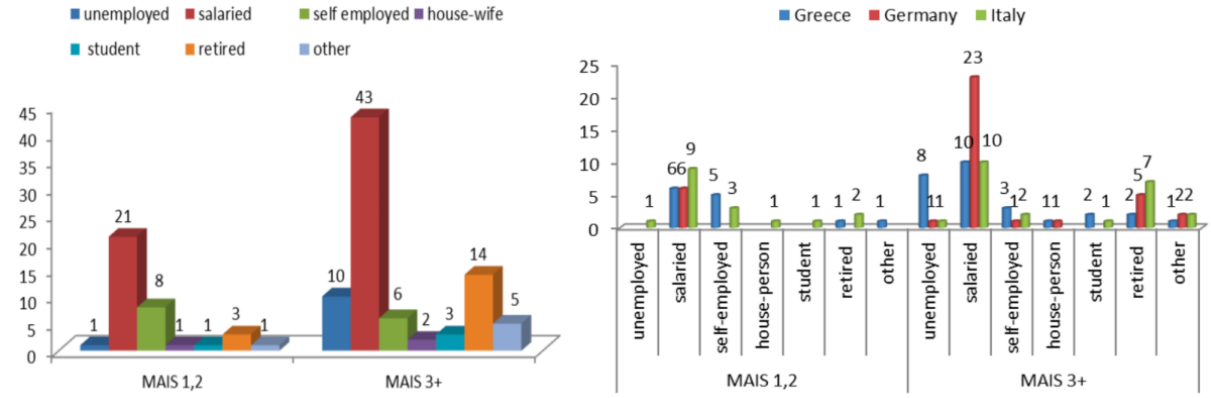


Figure 8–3: Occupational status among MAIS individuals and by country.

Looking at the annual income, most "MAIS 3+" cases in the three countries belonged to the lowest income groups (<15.000 and 15.000-28.000, respectively). Most "MAIS 3+" cases in Germany and in Italy reported an annual income of 15.001-28.000 while most of the "MAIS 3+" cases in Greece reported <15.000 annually (Figure 8–4).

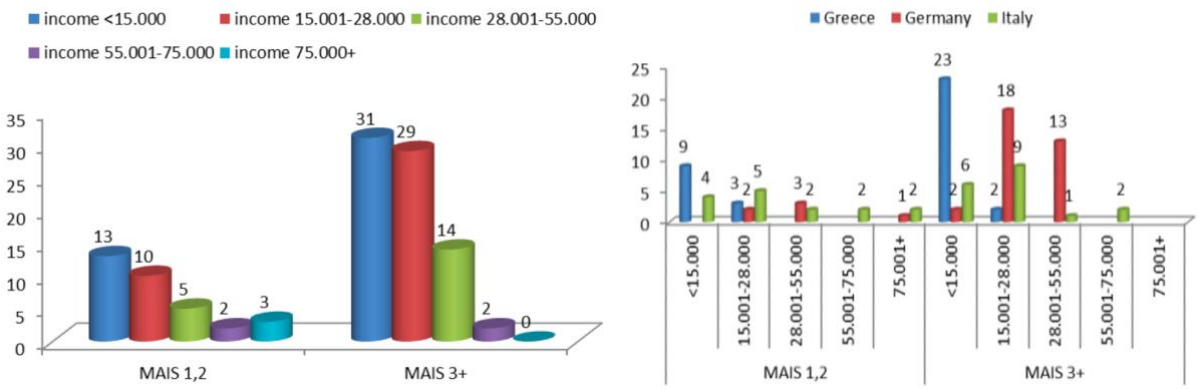


Figure 8–4: Annual income distribution for MAIS cases and by country.

Looking at the work-related changes among the patients (Figure 8–5), it is evident that the percentage of full-time employed individuals was reduced by more than 10.0% within the year after the injury (44.7% to 34.2%). At the same time, there was an increase of nearly 8.0% at 6 months and 6.0% at 12 months in the unemployment among the patients. The number of those retired on medical grounds was stable at 6 months and increased by 1.5% at 12 months after the injury. As for the country-specific situation, it is evident that within Greece, the number of full-time employed individuals was reduced by more than 13.0%, the number of unemployed was increased by more than 10.0% and the number of retired on medical grounds remained the same at 12 months after the injury. In Italy, the number of full-time employed individuals was reduced by more than 17.0% at 6 and was increased by more than 11.0% at 12 months after the injury. Similarly, unemployed individuals were increased by nearly 15.0% at 6 months but the increase was nearly 4.0% at 12 months after the injury. The number of individuals who retired on medical grounds in Italy was increased by almost 9.0% at 12 months after the injury.

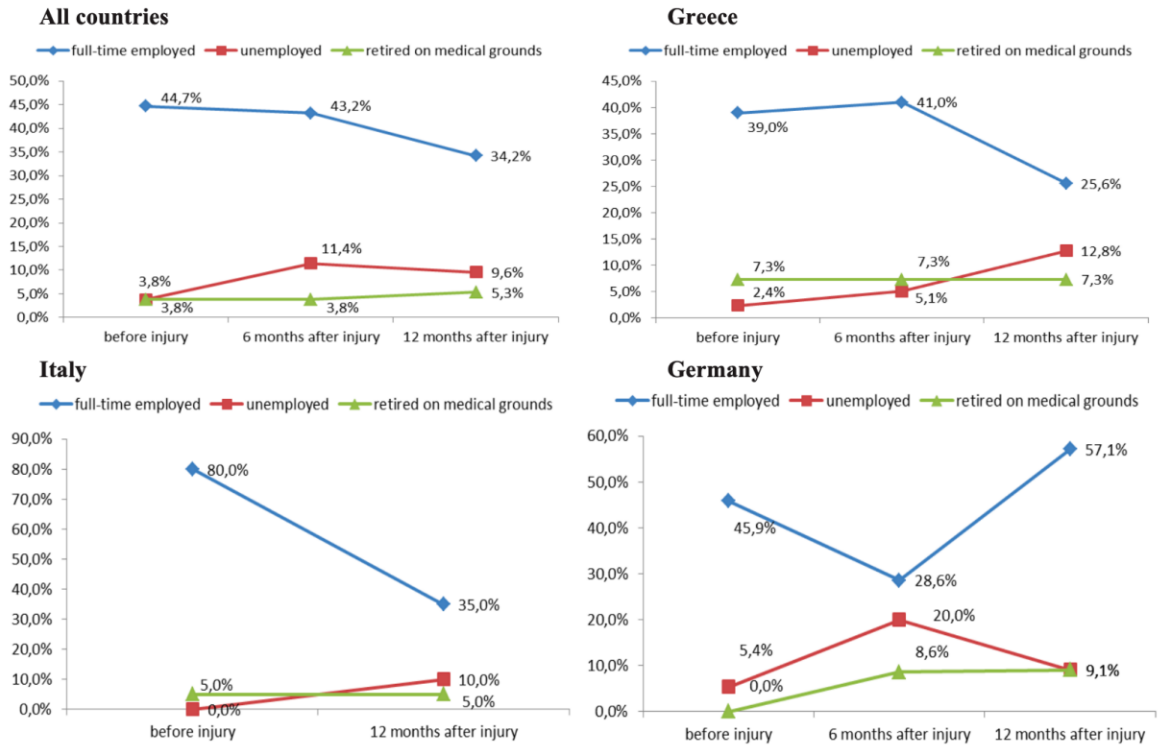


Figure 8–5: Employment changes post-injury (6 and 12 months).

8.2 Socioeconomic differences in out-of-pocket direct and indirect health expenditure

Italy recorded the highest total direct and indirect health expenditure (Figure 8–6).

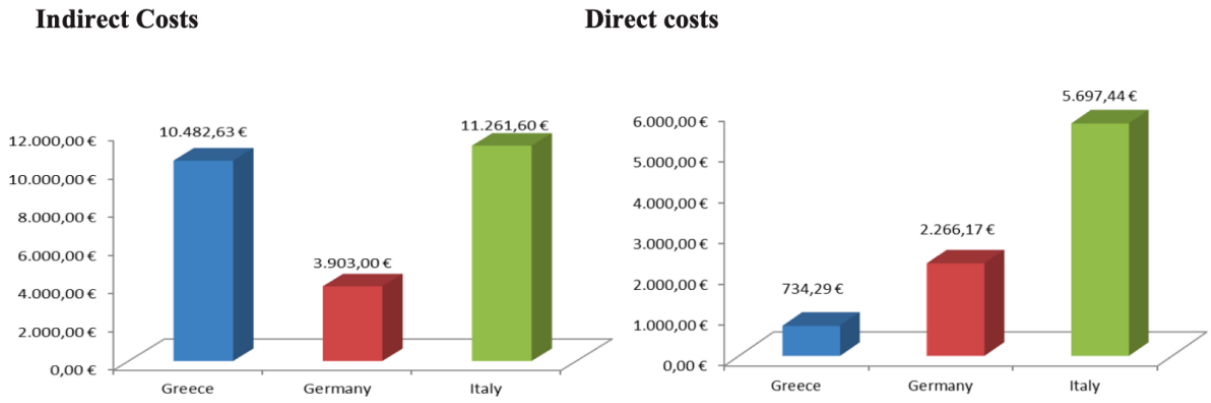


Figure 8–6: Total direct and indirect health expenditure by country.

Men demonstrated a higher total indirect health expenditure than women (9,415.76 € and 5,807.53 €, respectively) and women demonstrated a higher total direct health expenditure than men (5,285.65 € and 2,190.02 €, respectively). The age group of 25-49 years presented the highest total indirect health expenditure (13,112.77€) followed by the age group of >65 years (11,417.21 €). The age group of 50-64 years presented the highest total direct health expenditure (4,704.17€) followed by the age group of >65 years (3,725.96 €), see Figure 8–7.

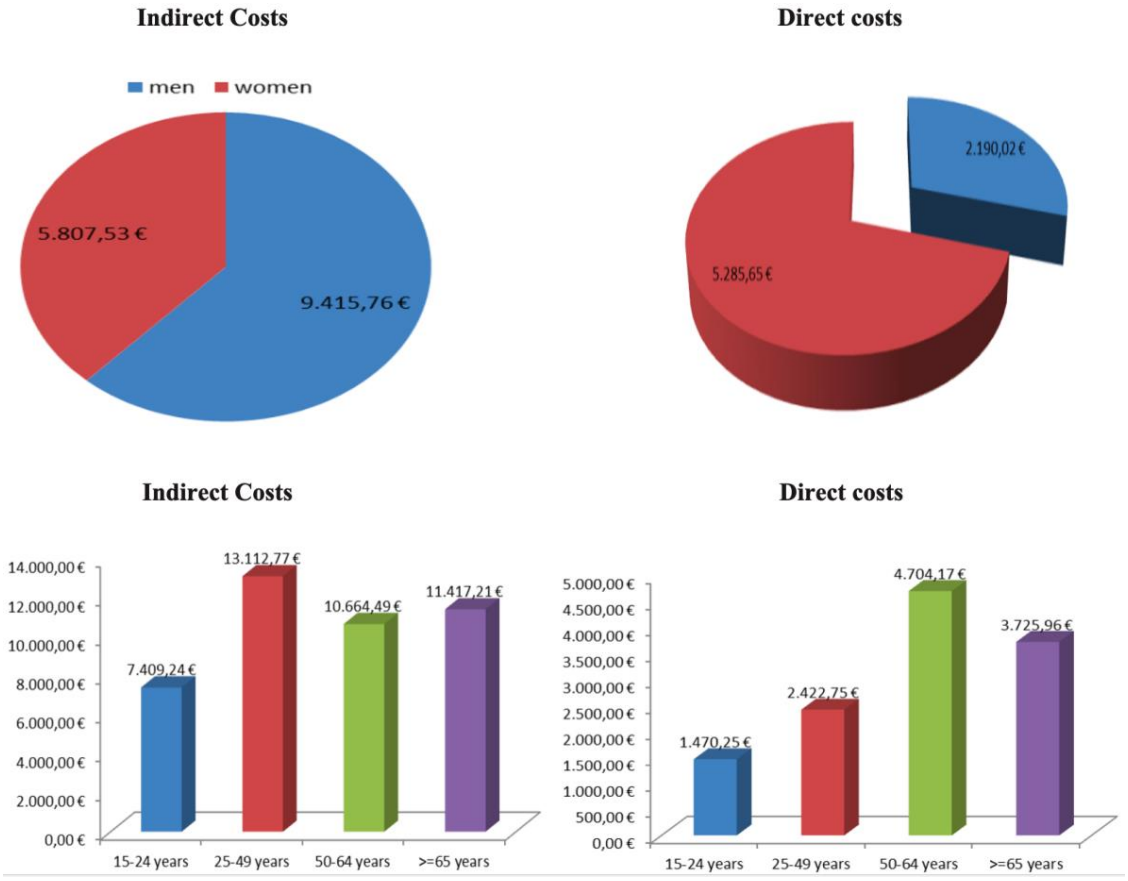


Figure 8–7: Indirect and direct expenditure by age group.

As for the type of road user (Figure 8–8), motorcyclists presented the highest total indirect health expenditure (9,685.72€) while pedestrians presented the highest total direct health expenditure (8,264.22€).

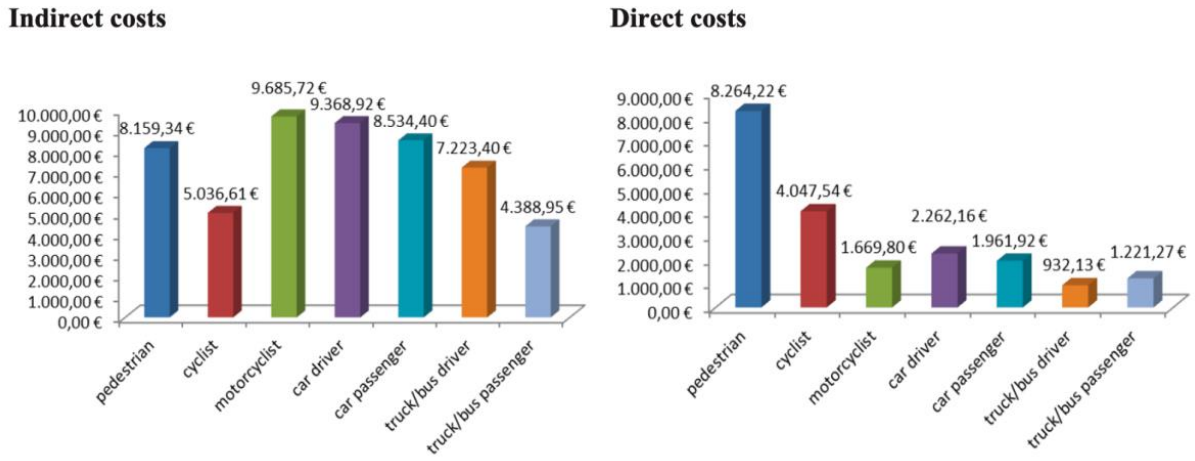


Figure 8–8: Total expenditure by road user.

As for the injury severity, "MAIS 1,2" cases presented both higher total direct and total indirect health expenditure as compared with "MAIS 3+" cases (Figure 8–9).

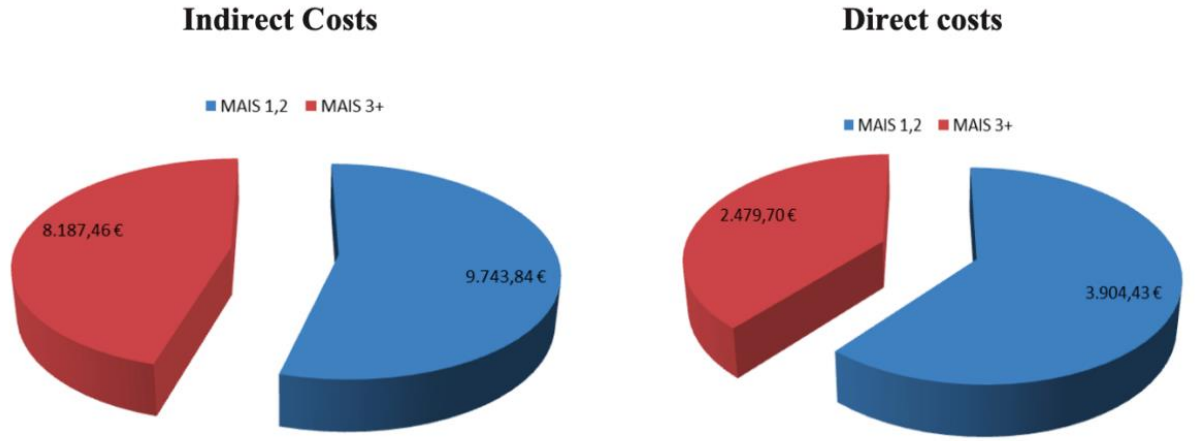


Figure 8–9: Health expenditure by MAIS severity (1,2 vs 3+).

Individuals who sustained the most severe injuries at the lower extremities reported the highest total indirect health expenditure (10,217.85€), see Figure 8–10, while those sustaining most severe injuries at the central body region (thorax, abdomen, spine, upper extremities) reported the highest total direct health expenditure (3,826.90 €). Individuals sustaining the most severe injuries at the upper body region demonstrated both the lowest total indirect (4,861.79 €) and the lowest total direct expenditure (1,568.70 €).

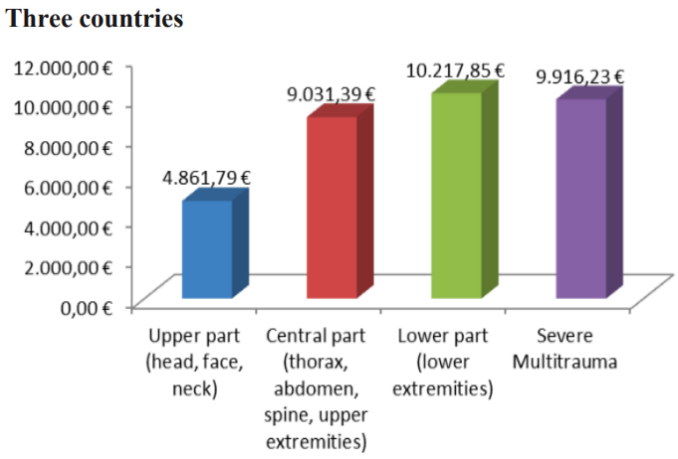
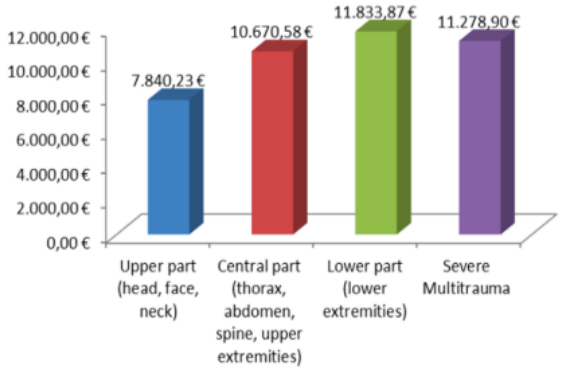


Figure 8–10: Indirect expenditure by most severe injury location.

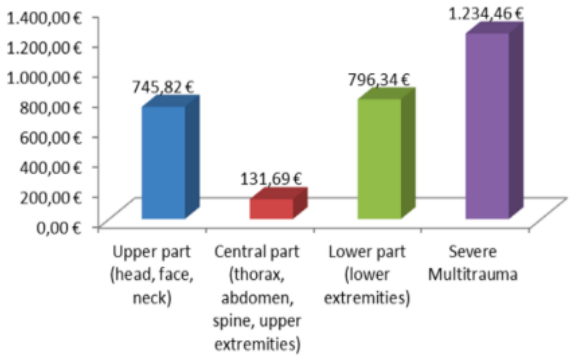
In Greece, individuals sustaining the most severe injuries at the lower extremities demonstrated the highest total indirect health expenditure (11,833.87 €) and those sustaining the most severe injuries at the upper body region demonstrated the lowest total indirect health expenditure (7,840.23 €), see Figure 8–11. A different pattern was observed in Germany and Italy, with individuals who sustained the most severe injuries at more than one body regions demonstrating the highest total indirect health expenditure (5,437.11€ and 13,032.68 € respectively) and those sustaining the most severe injuries at the upper body region demonstrating the lowest total indirect health expenditure (2,624.41€ and 4,127.83€, respectively). Looking at the direct health expenditure, in Greece and Germany, individuals sustaining the most severe injuries at more than one body regions demonstrated the highest total direct health expenditure (1,234.46€ and 4,486.34€, respectively), while in Italy those sustaining the most severe injuries at the central body region (thorax, abdomen, spine, upper extremities) reported the highest direct health expenditure (7,986.49 €).

Greece

Indirect costs

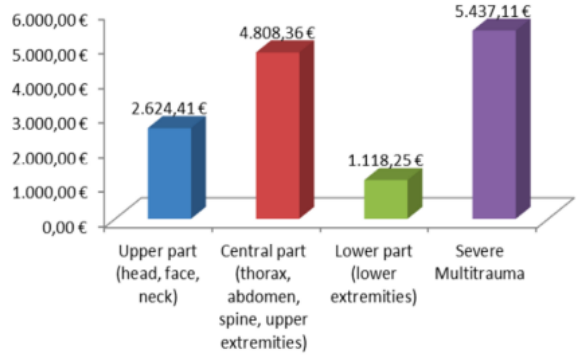


Direct costs

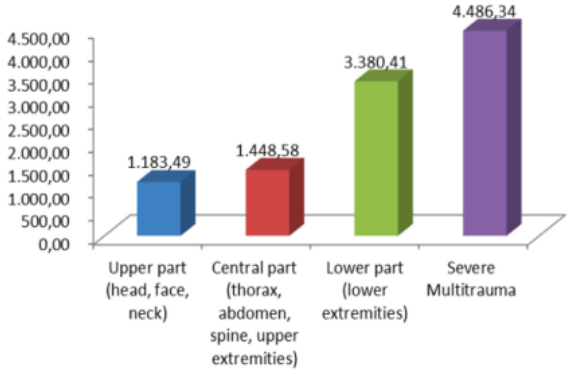


Germany

Indirect costs

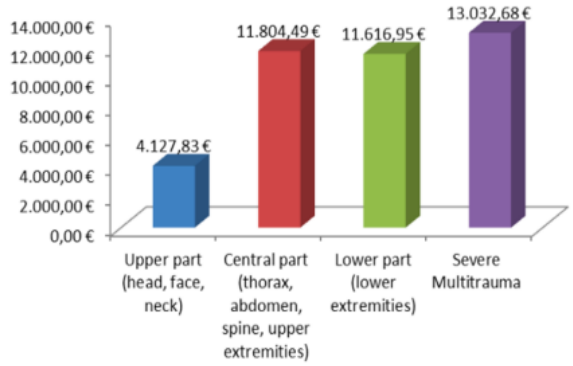


Direct costs



Italy

Indirect costs



Direct costs

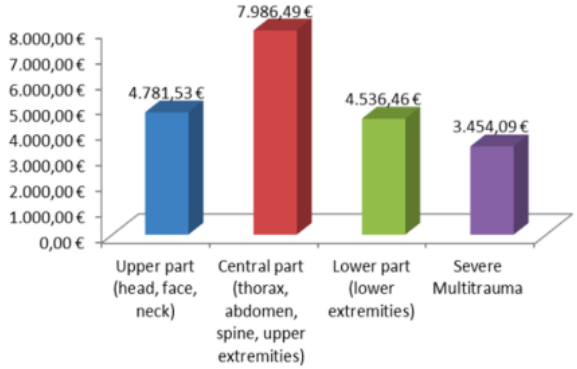


Figure 8–11: Indirect and direct costs by injury location per country.

8.3 Socioeconomic differences in hospitalization costs

A total of €2,050,167 was spent on hospitalization payments of the 120 patients who sustained injury in RTCs and were admitted to the ICUs of the collaborating hospitals in the three partner countries. Out of these hospitalization payments, €298.150 (€7,272 per person) was recorded in Greece, €1,382,565 (€35,450 per person) in Germany and €369,452 (€9,236 per person) in Italy (Figure 8–12).

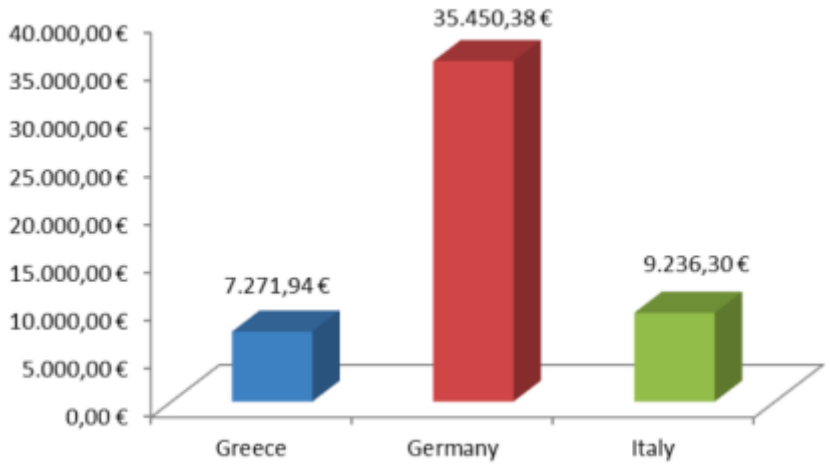


Figure 8–12: Total hospitalization costs by country.

There has been a gender difference in terms of hospitalization payments for road traffic injury, with men demonstrating higher overall hospitalization costs compared to women (€1,540,648 and €509,518, respectively), and accounting for 75.0% of the total hospital payments for road traffic injury (Figure 8–13). In contrast, women demonstrated higher average hospital costs as compared with men (€18,871 and €16,566 respectively). This difference was not shown to be statistically significant ($p>0.05$). As regards to the hospitalization costs by age group, the 25- to 49-year age group presented the highest total hospitalization costs (€846,032) accounting for nearly 41.0% of the total hospitalization payments for road traffic injury, followed by the 50- to 64-year age group (€607,008), which accounted for 29.6% of the total hospital payments ($p=0.005$). On the contrary, average hospitalization costs were highest for the 50- to 64-year age group (€23,346/ person) followed by the 65 years group (€17,597/ person). Statistically significant differences were demonstrated between the age groups "15-24 years" and "50-64 years" (Man Whitney U=220.000; p=.054) as well as between the age groups "25-49 years" and "50-64 years" (Man Whitney U=458.000; p=.005) in terms of hospitalization costs.

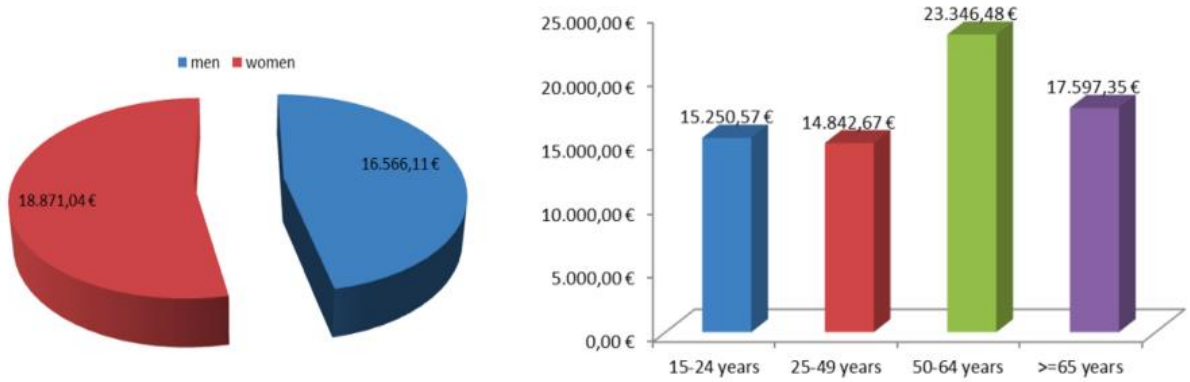


Figure 8–13: Hospitalization costs by gender. Hospitalization costs by age.

With respect to the hospitalization costs by road user group (Figure 8–14), motorcyclists presented the highest total hospitalization costs (€950,673) accounting for nearly 46.5% of the total hospitalization payments for road traffic injury, followed by car drivers (€563,328), accounting for 27.5% of the total hospital payments for injury of this kind. On average, motorcyclists presented the highest cost per person (€23,767) followed by truck/bus passengers (€19,691), but that is based only on two injured participants. Differences among the various road user groups were not shown to be statistically significant (p>0.005).

Total hospitalization costs were higher for MAIS3. compared to MAIS 1,2 (€1,765,022 and €283,899 respectively) and severely injured patients accounted for 86.0% of the total hospital payments for road traffic injuries; similarly, average hospital costs were higher by far for those severely injured (€21,265) than for those slightly injured (€7,886).

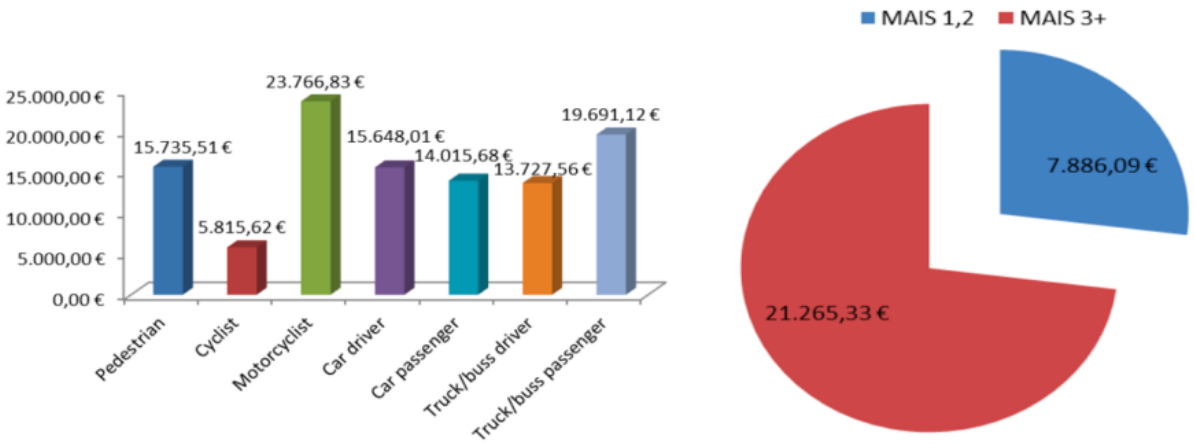


Figure 8–14: Hospitalization costs by road user. Hospitalization costs by MAIS cases.

As for the injury costs based on the body region (Figure 8–15) most severely affected by the injuries, it seems that victims severely affected at the central body region accounted for nearly 32.0% of the total hospitalization costs for road traffic injuries followed by those affected at the upper body region who accounted for another 31.0% of the total hospital costs of this kind. However, when looking into average costs, it is evident that hospitalization costs were by far higher for persons sustaining severe injuries at the upper body region (€24,502) as compared with other body regions. None of the aforementioned differences were shown to be statistically significant (p>0.05). In Germany and Italy, individuals sustaining the most severe injuries at the upper body region presented the highest hospitalization costs (43,515.54€ and

13,222.25 €, respectively), while in Greece, costs were higher for those sustaining the most severe injuries at the lower extremities (9,502.93 €).

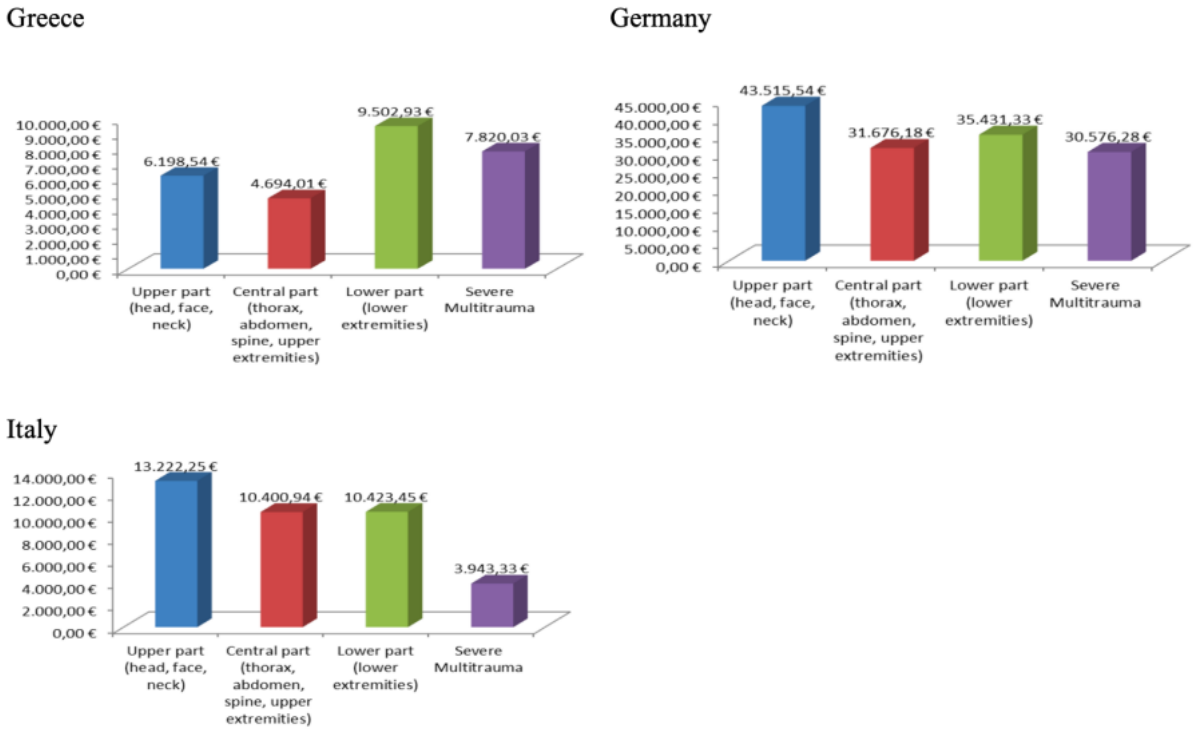


Figure 8–15: Hospitalization costs by most severely affected body region per country.

8.4 Socioeconomic differences in hospitalization costs

To estimate the effect of various socioeconomic variables on the health expenditure, multiple regression models were created for each cost category (direct cost, indirect cost, hospitalization cost) and similar models were created per country. The following parameters were used as independent variables upon recoded: age, height, weight, MAIS categories, body region injured, road user group, partner in collision. The following findings occurred from the analysis:

- Being a pedestrian in the total study sample was shown to be positively related with the total direct costs (compared with car occupants).
- Age was positively associated and height negatively associated with hospitalization costs, in the total study sample.
- Being a motorcyclist in the German sample was positively associated with hospitalization costs (compared with car occupants).
- Being a pedestrian in the German sample was negatively associated with total direct costs (compared with car occupants).
- Having a collision with a car was shown to be negatively associated with hospitalization costs, in the German sample.
- Being a motorcyclist in the Greek sample was negatively associated with total indirect costs (compared with car occupants).

8.5 Summary on long-term individual and health system expenditure.

Measuring the expenditure regarding a RTI is complex as it includes the kind of the expenditure measured, the gender of the participants, their country of habitation, the body region injured and the severity of the trauma as well as the type of the road user. In our sample, we have been able to identify that men are overrepresented in RTI victims treated in ICU and they also account for a higher percentage of indirect costs as compared to women. Women though account for higher hospitalization costs than men and they present a higher average direct expenditure as compared to men. Depending on the body region injured, individuals who sustained the most severe injuries at the lower extremities reported the highest indirect health expenditure while those sustaining most severe injuries in the central body region (thorax, abdomen, spine, upper extremities) reported the highest total direct health expenditure. Overall though, indirect expenditure seems to outweigh the direct expenditure. Also, age, height, the road user group and the partner in collision have been shown to affect the out-of-pocket health expenditure and/or the hospitalization costs. Interesting findings arise for specific age groups as well. Individuals aged 50–64 years account for higher hospitalization costs and higher average direct costs but individuals aged 25–29 years shoulder the highest average indirect costs. Regarding employment status, the percentage of full-time employed individuals was reduced by more than 10.0% within the year after the injury and unemployment increased by 6%. The number of those retired on medical grounds was increased by 1.5% at 12 months after the injury. Lastly, motorcyclists and four-wheel drivers are over-represented among the patients treated in ICU due to RTIs and account for the highest hospitalization costs.

9. Conclusion

The first task of work package 1 is to give an overview and an analysis of existing data on long-term consequences.

For the analysis of the long-term physical impairment only data from the EU project REHABIL AID could be used. It showed that due to the relatively low case numbers available in this project an analysis of the injured body parts is more often possible than the analysis of sustained long-term consequences due to the injuries. No significant data could be identified on behalf of cognitive impairment as a long-term result of a traffic accident. However it is likely that already mild traumatic brain injuries due to road traffic accidents and psychological sequelae due to accidents can cause long-term cognitive impairments. The share of e-scooters in accidents has risen in the last few years but still has a small share among all accident participants. Due to the lack of sufficient in-depth data on this type of road users an analysis with significant statements is difficult to date. For the analysis of bus occupants a dataset of GIDAS cases was available which led to the conclusion that bus accidents often do not involve a crash but rather a harsh driving manoeuvre like braking which causes injuries to the passengers. However there were not sufficient cases with bus occupants to foresee long-term consequences of those injuries.

Next to the long-term consequences resulting from the accident there are various factors (predictors) of the person involved in the accident that can have an influence on the outcome of the recovery and on the consequences of the accident. These should be taken into account when predicting the occurrence and developing measures of long-term consequences.

Concerning the individual and health system expenditure which was analysed using the REHABIL AID data the measurement of the expenditure is complex especially if different countries are involved. However the expenditures are dependent on the injured body regions and personal characteristics like age or sex.

In summary the analysis of long-term consequences showed to be difficult with the available data in this day and age. In national statistical data the consequences of accidents are only collected via the injury severity directly after the accident. The lack of data on long-term consequences including the socio economic costs becomes obvious and shows the need for research on long-term consequences and the possibility to collect these in-depth information in a structured way.

10. Abbreviations

Term	Definition
AIS	Abbreviated injury scale
GIDAS	German in-depth accident study
ISTAT	Istituto Nazionale di Statistica (Italian National Institute of Statistics)
LT(H)C	Long-term (health) consequences
MAIS	Maximum Abbreviated injury scale
MHH	Medizinische Hochschule Hannover (Hanover Medical School)
ONISR	Observatoire national interministériel de la sécurité routière
ProtAct-Us	ProtAct-Us from long-term consequences of road crashes
PU	Public
R	Report
RTC	Road traffic crash
WP	Work Package

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