A Conceptual Framework for Risk Assessment in Road Safety of Vulnerable Users

Mauro D'Apuzzo[1], Daniela Santilli[1](✉), Azzurra Evangelisti[1], and Vittorio Nicolosi[2]

[1] Department of Civil and Mechanical Engineering DICEM, University of Cassino and Southern Lazio, Cassino, Italy
{dapuzzo,daniela.santilli}@unicas.it

[2] Department of Enterprise Engineering "Mario Lucertini", University of Rome "Tor Vergata", Rome, Italy
nicolosi@uniroma2.it

Abstract. The risk-based engineering analyzes, created mainly to activate forecasting and prevention measures in response to the damage generated by natural disasters, have been extended to many other sectors. One of these is that relating to road safety. Over the last few decades, the European Union has pushed towards a noticeable improvement in road safety (EU roads are the safest in the world), but there are still too many deaths and injuries. It must be said that all the procedures and measures implemented so far in the road sector are aimed at reducing the hazard of the motorized component. In fact, the advent of ITS onboard devices has enormously improved the safety of drivers and passengers, but almost nothing has been done to protect vulnerable users. Although car manufacturers are recently pay more attention to this latter issue, road safety engineers can play a critical role in identifying and evaluating the various accident scenarios and then selecting optimal countermeasures. In this paper, following a review of risk based methodologies, an original risk-based methodological approach is proposed for pedestrian. The ultimate goal is to bring, as requested by the European Community, a drastic reduction in the number and consequences of accidents involving vulnerable users.

Keywords: Vulnerable user · Road safety · Hazard · Vulnerability

1 Risk Definition

Due to climate change and global warming, natural disasters involving transport infrastructures is recently increasing. These are significant damage to both the natural and built environment with deaths and injuries, and long-term damage to communities as well as to the social aspects linked to the reconstruction and restoration of the functionality of structures and infrastructures. This requires long recovery times to return to "pre-disaster" conditions, therefore countries are moving towards a risk reduction policy with the aim of predicting the effects, on the most relevant territorial assets, to

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minimize their impact. This allows stakeholders (planners, public administrators, service managers, emergency departments, private investors, insurance companies, etc.) to take mitigation actions [1, 2].

However, it is necessary to clarify because in common language the terms "hazard" and "risk" are used as synonyms, even if from a technical point of view they express different concepts. In fact, according to the legislation [3], the hazard is the potential of a specific entity (machine, equipment, plant, substance, process, system, etc.) to cause damage. The hazard can, therefore, be defined as a "source of potential damage".

While, the risk depends on the interaction between the source of danger and the person. Unlike the hazard that is characterized by its physical objectivity, the risk is linked to the hypothesis that a future event could cause damage.

The first risk assessment strategies were developed in the 1970s, when the international community began to emphasize the need to plan and prevent natural phenomena that were becoming an obstacle to settlement development. Therefore, the effects of natural disasters began to be considered in humanitarian and social terms as well as economic and developmental ones, especially for those countries where urbanization involves areas subject to natural events (earthquakes, floods, tsunamis, fires, etc.). After years of research on the main natural hazards (phenomena) of meteorological, geological and geophysical origin in 1979, the conference of the United Nations Disaster Relief Office [4] defined risk as the predicted number of lives lost, injured, property damage and business disruption due to a particular natural phenomenon. Therefore, risk was defined as the product of a specific risk (i.e. the degree of expected loss due to a natural phenomenon, a function of both danger and vulnerability) and elements at risk.

$$Risk = Hazard \cdot Consequences \tag{1}$$

The UNDRO Committee also highlighted that in order to assess the potential loss due to a given natural hazard, the following must be taken into consideration:

- The randomness of natural hazards at a given site;
- The role of existing structures which have their intrinsic vulnerability;
- The importance of the elements (population, housing, economic activities, etc.) possibly affected, called "elements at risk";
- The definition of the expected risk over a period of time.

So to emphasize both the concept of chance or possibility (for example, the risk of an accident) of potential losses, for a given cause, place and period, the risk can simply be expressed as the product of three integral components, namely danger, vulnerability (of buildings, infrastructures and population) and exposure of these resources present in the study area. It is a probabilistic estimate that can be evaluated as:

$$R_0 = H \cdot V \cdot E \tag{2}$$

where is it:

R_0 is the risk referred to the assets displayed in the area of interest, expressed as far as possible in terms of probability or frequency of occurrence of predefined consequences;

H expresses the danger of the area of interest (as it increases, the risk increases); "A potentially damaging physical event, phenomenon and/or human activity, which may cause loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can be single, sequential or combined in their origin and effects" [5];

E expresses the exposure in the area of interest (as it increases, the risk increases); is the measure of possible future losses that may arise from an activity or event or as reported by Kolluru et al. [6] exposure is the process by which an organism comes into contact with a hazard;

V expresses the vulnerability of the goods exposed (as it increases, the risk increases); "The characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made disaster - noting that vulnerability is made up of many political-institutional, economic and socio-cultural factors" [7, 8].

This expression of risk is very broad both because it can refer to any type of hazard and because for a certain type of hazard there is no single risk assessment.

It can be generalized by considering x the effects of natural phenomena on the site, whose distribution is the function ϕ (x) which represents the probability of exceeding each value of x within the reference period. It is therefore possible to define the functions F (x) = 1 − ϕ (x) or p (x) = dF/dx which respectively represent the probability that x is not exceeded or the probability density function. Since vulnerability represents the expected damage on an entity (structure or population) induced by a phenomenon of a given magnitude, it can be written as $\alpha = \alpha$ (x). To evaluate the probability of failure (df) associated with the risk probability x between x and x + dx can be written as (Fig. 1a):

$$df = p_H F_s dx \tag{3}$$

Where

p_H (x) the probability density function;

F_S the probability of exceeding.

Similarly, from Fig. 1b, the probability of failure (*df*) associated with the probability of the strength x ranging between x and x + dx is:

$$df = p_s \phi_H dx \tag{4}$$

Where

p_S density function of distribution of the mechanical properties of the structure;

ϕ_H the probability of exceedance.

The elementary specific risk associated with the probability of the entity of the event between x and x + ds is:

$$\frac{dr}{(er)} = \alpha(x) F_s p_H dx = \alpha(x) \Phi_H p_s dx \tag{5}$$

where (er) are the elements at risk (all the other parameters are described previously).

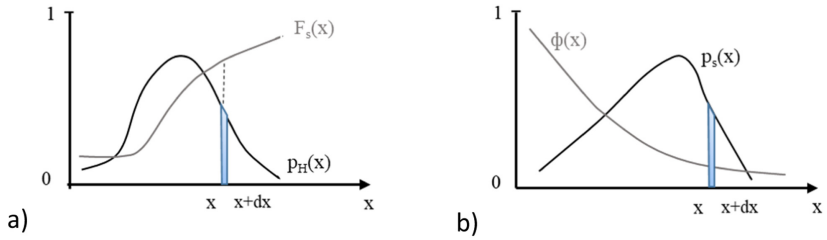


Fig. 1. Functional forms of the hazard and structural strength probabilities: a) probability densi-ty function pH (x) and probability of non-exceedance a level of structural strength FS(x) for a given value of the magnitude x; b) probability of exceedance ϕH(x) and probability density function of a structural strength ps(x) for a given value of the magnitude x (modified after [4]).

Following the UNDRO Conference, from 1 January 1990, the International Framework of Action for the International Decade for Natural Disaster Reduction (IDNDR) initiated the Yokohama strategy with the aim of reducing loss of life, damage to property, the social and economic hardships caused by "natural disasters", especially in developing countries. This strategy identified gaps related to governance, risk identification, assessment, monitoring and early warning, knowledge management and education, reduction of underlying risk factors, preparation for effective response and recovery. Starting from these shortcomings, the Hyogo action was then launched (2005–2015) aimed at making countries aware of their primary role in the prevention and reduction of the risk of disasters. This has pushed them towards international cooperation policies and the development of regional strategies with the creation of global and regional platforms for disasters. While in the past the protection of social and economic development from external shocks was considered, now the goal is growth and development planning to manage risks holistically; which means the establishment of multidisciplinary approaches to promote sustainable economic and social growth, protect environmental health conditions and strengthen resilience (i.e. take proactive behaviours, ready to survive disasters and maintain economic competitiveness) and stability. This gave rise to the Sendai Framework 2015–2030 plan [9] which is aimed at strengthening risk governance by developing risk prevention, mitigation and management activities, in order to reduce the risk of catastrophes and loss of life, human resources, livelihoods and health, and the economic, physical, social, cultural and environmental assets of people, businesses, communities and countries.

1.1 Risk Analysis

Therefore, starting from a mainly geotechnical risk definition, risk assessment processes (or risk analysis) are being tested in various sectors.

The risk assessment consists of a set of activities that make it possible to identify and quantify the risk, to then put in place the appropriate prevention and protection measures, to activate all those activities measures of a technical, organizational and procedural nature that make up the so-called process of "risk treatment" and more generally "risk management" (Fig. 2).

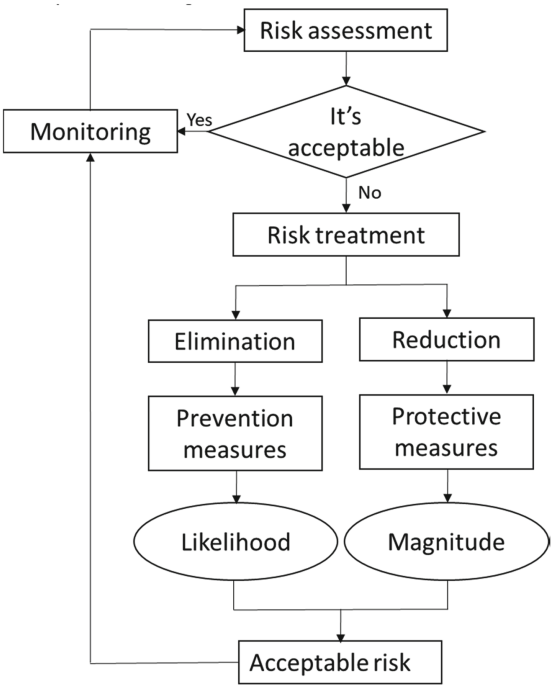


Fig. 2. Flow chart adapted from [10].

In general, the process starts with the identification of risk factors and then estimates the identified risks. To do this, probabilistic approaches can be used that evaluate both the probability of occurrence (Pr) and the magnitude of the damage (M).

These approaches can be grouped into two macro-categories:

– quantitative or semi-quantitative approach;
– qualitative approach.

The first is based on the use of mathematical models, which use inferential statistical methods; it is used in specific contexts, where the analysis of safety standards must be very precise and accurate. Quantitative analyzes provide a more objective understanding, however, their effectiveness is fundamentally based on the quality of the information available, that is the number and accuracy of the data, which represent various possible situations.

Whenever possible, a quantitative approach should be preferred to be more objective and examine the system in more detail, but supplementation with qualitative analysis should be considered. An appropriate combination to sum the advantage of both approaches becomes crucial when not all factors can be parameterized.

While the qualitative approach is also called "subjective" as it is based on the "expert judgment" of the risk analyst, whose level of competence and the quality of the data acquired in the preliminary phase must be reliable. Qualitative methods offer analysis without detailed information, are performed with intuitive and subjective processes and can lead to different results/conclusions depending on who uses them. Although suspected of leading to subjective conclusions, they offer the possibility of considering factors that are difficult to quantify, such as those related to human behavior, and sometimes lead to an adequate risk assessment. There are several theories that allow you to transform qualitative into quantitative assessment (e.g., probability of imprecise interval, possibility and theories of evidence), an overview is provided by Tesfamariam and Goda [11].

In qualitative estimation, the definition of scales is used, in which both the probability and magnitude of graduation are explicitly defined (table 1).

Table 1. Qualitative estimation scale relationship between probability and damage.

Likelihood	Magnitude
Very low	Negligible
Medium low	Moderate
Medium high	Remarkable
High	Huge

Based on this estimate, the analyst identifies three classes of risk: HIGH RISK, MEDIUM RISK, LOW RISK which determine different levels and priorities of intervention (Table 2).

Table 2. Levels and priorities of intervention definitions.

Likelihood	Magnitude	Risk	Intervention
High	Huge	High	The measures are urgent. The intervention plan goes beyond cost/benefit assessments
High	Remarkable		
Medium high	Huge		
High	Moderate	Medium	Plan and apply prevention and protection measures; these must be checked to assess the effectiveness of the risk reduction process
High	Negligible		
Medium high	Remarkable		
Medium high	Moderate		
Medium high	Negligible		
Medium low	Huge		

(*continued*)

Table 2. (*continued*)

Likelihood	Magnitude	Risk	Intervention
Medium low	Remarkable		
Medium low	Moderate		
Very low	Huge		
Very low	Remarkable		
Medium low	Negligible	Low	No interventions are necessary but it is necessary to continue to monitor by evaluating possible future improvements
Very low	Moderate		
Very low	Negligible		

Once the probability and magnitude have been estimated, graphical representations have used that highlight the assessment carried out for each risk. Among the most used is the "risk matrix" which is obtained by plotting in a Cartesian graph, the probability scale in the ordinate and the magnitude scale in the abscissa (Fig. 3).

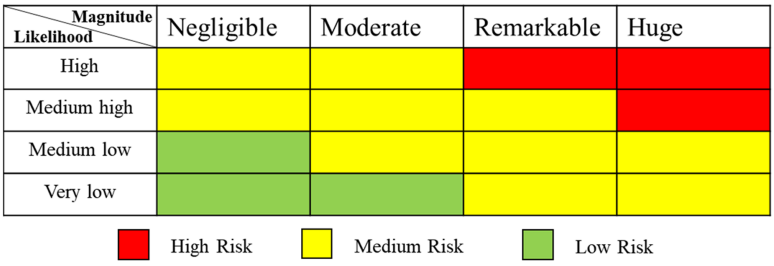


Fig. 3. Risk matrix (Color figure online)

The next step is the "risk weighting" phase which serves to determine whether the risk is acceptable and to what extent. That is, it is necessary to establish for each risk its limit of acceptability, beyond which it must be reduced with prevention and protection measures. The acceptability of the risk depends on several factors, including the phenomenon (whether or not controllable), the type and nature of the consequences, the short and long-term effects, the benefits obtained, the preparedness for natural hazards and the influence of individual and total risk. The definition of acceptability limits depends on legal constraints, rather than on technical standards or improvement practices. Therefore it is required that, in order to satisfy the safety conditions, the measured risk is to a lesser extent equal to the acceptable one. Therefore, once the pre-mitigation risk R0 has been assessed, a benefit-cost analysis must be carried out to assess the suitability of the mitigation. In general terms, it can include risk reduction (active mitigation), vulnerability reduction (passive mitigation) or both options (active and passive mitigation).

Regardless of the type, assuming a mitigation cost equal to U_d, the residual risk R'_d can be calculated:

$$R'_d = H' \cdot V' \cdot E' + U_d \tag{6}$$

Where:

H′, V′ and E′ represent the new terms of Hazard, Vulnerability and Exposure respectively after mitigation.

Starting from the same risk level R0, there are two different scenarios:

- R′d < R0 there is a convenient situation that justifies the adoption of countermeasures;
- R′d > R0 a situation of non-economic convenience emerges. While effective countermeasures reduce hazard or vulnerability, their cost has resulted in a residual risk greater than pre-mitigation.

At the end of this phase, a risk map is obtained which highlights the unacceptable risks that must be reduced by adopting measures that will be programmed and planned with a prioritization process. The general criterion is based on the entity of the risk, i.e. the higher the estimated risk level, the higher the priority of intervention.

So the priority is divided into three categories:

- High Priority: urgent interventions to be implemented in the short term, for unacceptable risk situations according to previous regulations.
- Medium Priority: interventions to be implemented in the medium term, for risk situations to be reduced to acceptable values within the terms set by the regulations.
- Low Priority: interventions to be implemented in the long term for situations of acceptable risk, but aimed at the continuous improvement of safety (further reduction of the risk).

The last phase of risk management is the monitoring or the periodic process of control and measurement of the risk parameters, review and weighting of new and/or modified risks following the changes made to the environments.

2 Road Safety Risk

The risk arising from the evaluation of the protection and prevention measures to be adopted in the event of natural disasters can actually be applied in various fields. Precisely from the understanding and application of risk estimation techniques it is possible to evaluate road safety[12]. The main task in the road safety audit is to identify the elements of danger that could cause death or injury. So usually when we talk about road risk we implicitly refer to accidents (the severity and frequency of which must be defined) [13, 14].

These, in fact, represent a problem of absolute priority for public health since in addition to the loss of human life they generate enormous social and human costs, to which are added high economic costs, which make the issue of road safety a topic of enormous importance for the prevention departments and health systems of all countries.

There is talk of a social scourge that causes almost 10 deaths and about 700 people with injuries every day.

The causes can be attributed to numerous risk factors:

- related to the person or health conditions, age, the intake of compromising drugs, attention, balance and reflexes;
- lifestyles that involve the consumption of alcohol and psycho-altering substances, and incorrect driving behavior (use of cell phones, inattention, excessive speed, failure to use protection systems);
- safety of roads and vehicles;
- social: the poor socio-economic conditions have less access to training and information resources on prevention measures and more generally to the acquisition of a culture of safety on the roads.

To obtain a good reduction in the number and severity of road accidents, a program of prevention interventions is required that considers the multiple factors that underlie a certain type of accident and that simultaneously weigh on the risk.

Globally, the World Health Organization (WHO) through the World report on road traffic injury prevention [15] encourages countries to plan a multi-sector strategy for road safety, which takes into consideration the needs of each one by implementing specific intervention projects.

In Europe, therefore, the European Commission has promoted a road safety program which identifies some areas of intervention such as: encouraging road users to behave more responsibly, making vehicles safer thanks to technological innovations, improving road infrastructures through information and communication technologies, collect and analyze data relating to physical injuries due to road accidents.

In Italy, according to Istat estimates, since 2007 [16] there has been an average reduction in accidents with injured people of about 3% every year. This reduction is explained by the fact that users have begun to use alternative means of transport to private vehicles.

It has been understood that, in order to reduce the risk of an accident and know the result that can be obtained in terms of safety, it is necessary to go beyond simple compliance with the Highway Code or awareness of potential damage. It is essential to focus on techniques and tools for forecasting events on the road. Therefore, by systematically analyzing the information of "near miss" accident situations, it is possible to implement the related corrective actions.

Some researchers who have dealt with the evaluation of road safety [17, 18] have defined the risk as:

$$Risk = Exposure \cdot Hazard \cdot Vulnerability \tag{7}$$

where:
Exposure: quantifies the exposure of road users to potential road hazards;
Hazard: quantifies the possibility that a vehicle or user is involved in a collision;
Vulnerability: quantifies the severity level resulting from potential collisions.

It can therefore be observed that, with respect to the risk defined previously for natural phenomena, there is an inversion of the terms, but the assessment procedure remains the same.

Basing on this approach a conceptual framework has been proposed to evaluate the road safety risk for vulnerable user, namely pedestrian. The risk thus defined is therefore a function of multiple variables whose correlations are outlined in the following flow chart (Fig. 4).

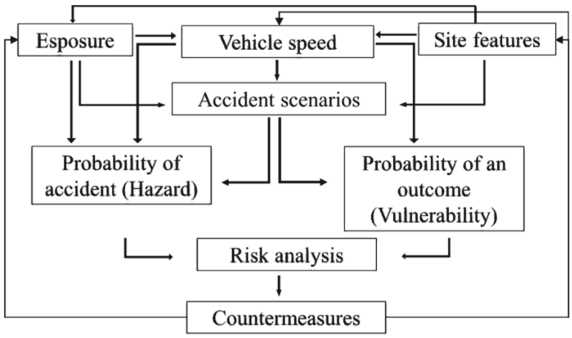


Fig. 4. Summary scheme of the procedure.

Therefore, once the global risk has been quantified, it is possible to arrange interventions that will improve exposure, vehicle speed and site conditions.

In order to being assessing the risk of having an accident in the study area, it is necessary to know the history of accidents and their characteristics, in order to bring them back to a typical scenario.

Once the accident scene has been identified, the three key parameters of the risk begin to be assessed.

2.1 Exposure

To identify the factors that best predict where and when accidents are likely to occur, exposure needs to be assessed. This is understood as the assessment of potential arrests under sudden conditions. When it comes to exposure, both vehicular and pedestrian flows are involved. The first requires knowledge of the traffic in transit on the section of the road network to be analyzed; this can be obtained from survey-based models or from simplified or forecast models. While for the estimation of cycle-pedestrian flows, there are no consolidated models, therefore direct (based on socio-economic and demographic variables) or forecast models (configurational or four-stage, similar to vehicular ones) are used.

Vehicular Flows Exposure

One of the factors that influence the exposure linked to vehicular flows is the speed held by the vehicles, which in turn is a function of both the characteristics of the site and the flows themselves. Many studies link road safety to speed, but the relationships between

risk (intended for example as the number of deaths on the road per distance travelled) and speed are almost absent.

The underlying problem is the lack of data collected or their poor quality, i.e. in the databases or in the reports of the law enforcement agencies there is an underestimation of the reports of accidents according to the severity, the number of victims, the number of vehicles involved, location, etc. This indicates that the relationship between speed and risk of collision is based on the number of collisions observed with serious injuries and in strategic locations, but little or nothing is known about accidents with minor injuries or localized in little-known areas, so the problem is underestimated. To overcome the problem of localization relating to areas that are neither urban nor rural, an alternative method could be to consider the real speeds recorded on a road section by extrapolating them from the black boxes mounted on cars (the Floating Car Data, FCD) [19]. Once these data have been obtained, it is possible to evaluate the speeds also in areas other than urban or rural, or for transition areas (Fig. 5).

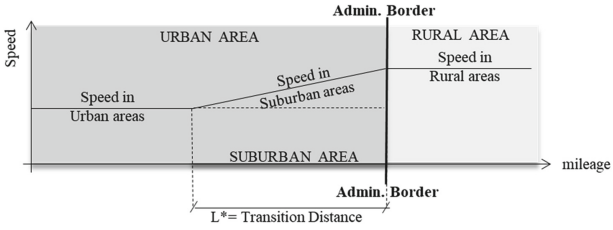


Fig. 5. The transition length concept.

This area represents the space of passage between a rural to an urban area in which, however, the user is still unable to realize the passage and therefore may not adopt a suitable speed. Formally, the transition between the rural and the urban environment is highlighted by warning signs that are displayed at the entrance to urban areas. Often these signs are associated with specific urban speed limits. However, it must be recognized that "official" administrative boundaries do not always express the real boundary between the urban environment and the surrounding areas.

Therefore it is possible to apply a generalized predictive model that starts from the re-calibration and readjustment of the literature models.

Pedestrian Flows

The estimation of the exposure of pedestrian flows can be approached starting from the use of configurational methodological tools [20] which will then be enriched with "demand-driven" models (four-stage) which will also allow obtaining estimates of the cycle flow. The configurational analysis considers only the connectivity of the network, so the more this is connected, the greater the connectivity of the sections. This exemplified approach has been enriched by integrating the analysis with behavioural models deriving from the transport analysis. The results of the hybrid approach obtained can then be correlated to the pedestrians observed on the network in order to understand the goodness of the estimate.

In order to improve the estimation of pedestrian flows and to evaluate cycling flows, the hybrid configurational model can be enriched using the four-stage model (similar to vehicular) starting from literature models. This allows to obtain an estimate of the flows and distribute them on the network so as to be able to understand where it is necessary to intervene to redevelop the area.

Hazard

Whenever the user enters a road, he is exposed to accept the danger and therefore the risk of being injured. In order to evaluate the hazard it is necessary to understand if the user correctly perceives the environment crossed, this requires an analysis of the site.

So first of all, it must be understood in what administrative environment you are, then let's talk about urban or rural context. The urban area is that set of buildings, delimited along the access roads by the appropriate start and end signs [21]. In which the set of buildings includes a continuous grouping, albeit interspersed with streets, squares, gardens or the like, consisting of no less than twenty-five buildings and areas of public use with vehicular or pedestrian accesses on the street. Anything that does not fit this definition is rural. It should be emphasized that the boundaries between the two areas are never clearly defined; however, formally, in most Western countries, urban limits or "administrative boundaries" are identified with vertical entry warning signs usually associated with speed limits.

Depending on the context, there is a greater chance of coming into conflict with other users, therefore it is necessary to take into account the presence of local attractions, such as schools, hospitals, shopping centers or any other activity that may generate greater crowding.

In addition to other users, further sources of danger are linked to the presence of obstacles on the route which are often not correctly displayed due to poor visibility conditions. Visibility is defined as the minimum stopping distance, this depends on many factors such as speed, the conditions of the road surface (the type of road surface, maintenance status, etc.), the condition and pressure of the tires, the characteristics and condition of the vehicle's braking system, the weather conditions as well as the geometric characteristics of the site (considering the road as the sum of straights and curves, number of lanes, longitudinal and transverse slope, etc.).

Vulnerability

To assess the risk, vulnerability remains to be defined. This is the probability, conditioned by the type of accident, that a vulnerable user suffers damage (injured or dead) or that the driver suffers damage (uninjured, injured or deceased).

In addition to a security point of view, vulnerability is seen as a problem of reduced accessibility that occurs for various reasons. In general, accessibility is understood as "ease of access", or the opportunity provided by the transport system for users to carry out an activity [22]. Improving accessibility means increasing the number of routes or the quantity of services considering low costs.

Estimating vulnerability means studying all those events, of a more or less sudden and/or unpredictable nature, which cause circulation problems. These events depend on adverse weather conditions, rather than physical breakdowns or road accidents, or planned road works, etc. Depending on the event and the category, there is a variation

in terms of frequency, predictability, geographical extension, etc. To achieve a reduction in vulnerability it is necessary to limit the risks involved in various incidents; this implies the need to identify a spectrum of accidents, collect data on the probabilities and consequences of these, having done this it will be possible to establish experiments to identify acceptability values, as well as investigate and evaluate the effects of possible mitigation measures and strategies for improvement.

Numerous relationships are reported in the literature that considers the links between stress characteristics, kinematic or mechanical magnitudes of the impact of the occupants, but there are still few of them regarding vulnerable users. The basic problem is that the existing ones are based on simulations with corpses or with limited data-sets in terms of location, severity and number of accidents, necessary for the calibration and validation of the models.

Hence the need to create a virtual laboratory that through multibody numerical simulations, as the position (front, side), age, weight and height of the pedestrian, vehicle fronts and travel speed vary, allows obtaining objective kinematic parameters (acceleration, speed, etc.) or mechanical (moments, shear, normal stresses, etc.) with which to enrich the vulnerability functions.

Studies on head injuries are being launched at a preliminary phase, since it is the part of the body that has a high probability of death, using the scale based on damage, disability and social cost, in which the long-term consequences are assessed and the influence that injuries have on the patient's quality of life.

The most used criterion is the Head Injury Criterion (HIC) [2, 23] which is estimated with an iterative process. Then to identify the level of damage, the HIC was correlated with the Abbreviated Injury Scale (AIS) [25–27] which assigns a score from 0 to 6 and using logistic functions from the literature, the probability of fatality was obtained.

In collisions between vehicle and pedestrian, there is different kinematics according to the impact speed, the pedestrian position, the different height and length of the bumper and the bonnet inclination angles; this means that the pedestrian impacts the various regions of the human body (e.g. head and thorax) in a different way also based on his build. From the simulations, it is observed that among pedestrians the age group most likely to die from a blow to the head are adults, while young people and children are more likely to be injured.

3 Conclusions

Despite the large number of deaths and injuries due to road accidents, there is still no clear regulation according to which the safety assessment for vulnerable users is reported. The goal of this study is to identify a procedure for estimating the main risk factors starting from microscopic analyzes. The results of these analyzes can then be integrated at a macroscopic level to define and predict safety performance as well as predict the probability of collision.

Starting from the traffic and cycling-pedestrian data, from the accident data and from the speed estimates, it is possible to identify blackspots i.e. those points or section of the road network that present anomalous concentrations of accidents. Once the risk of each road section has been identified, it is necessary, before implementing the proposed

interventions, to evaluate the benefits that these would bring and the respective costs. Until now, road safety analysts have relied on personal experience in order to make reliable forecasts, thus working subjectively; to avoid this, analysis methodologies have been developed that take into account the correlations between "cause" (man - road - environment) and "effect" (occurrence of the accident). These methodologies, typical of the engineering field, try to identify links of an empirical nature between the occurrence of the generic accident and the multiplicity of factors that make up the road environment, to the point of proposing mathematical models for forecasting purposes. In the Italian context, such models do not yet exist, so it is intended to apply macroscopic models calibrated in the international scientific literature (cf. Highway Safety Manual recently released in United States [28]) to transpose them to Italian context and calibrate corresponding Safety Performance Functions (SPFs). These latter mathematical tools, based on statistical analysis, evaluate the impact in terms of the number of accidents, as a function of the characteristics of the site and of the exposure. SPFs, refer to basic conditions but can be applied to different study conditions with the use of accident modification factors (Crash Modification Factor - CMF) that take into account specific local site-conditions.

Once the procedure will be developed and applied, it will be possible to evaluate, depending on the characteristics of the site and the type of risks present in the area, the countermeasures to be adopted to increase safety.

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