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ORIGINAL ARTICLE

Analysis of road accidents fatalities: the impact of socio-economic factors and innovative solution strategies

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ABSTRACT

In this work we present an experiment of guided innovation in the frame of the Innovation for Change program, where a group of students is called to solve a given challenge with innovative solutions, by applying methodological approaches throughout the all process. The problem under analysis is 'road crash fatalities', with a focus on the consequences of a poor post-crash care management. The solution is developed through a series of steps, such as problem definition, brainstorming sessions and interviews with stakeholders. Finally, the outputs of this process are presented as well as the designed solution, called EyeWay, which exploits already available technologies to perform automatic accident detection and shorten the crash notification time.

Keywords: Road safety; fatalities, post-crash care.

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INTRODUCTION

This paper describes the methods and processes behind an experiment of guided innovation. In this kind of experiments, multidisciplinary teams face relevant problems and try to solve them by exploiting methodological innovation procedures.

The initial challenge assigned to the team was quite broad, namely "Safety for workers, builders and drivers on highways". Due to the relevance of the problem and the affinity with team members' vision, the team decided to focus the attention on drivers' safety[1]. Indeed, road traffic accidents reached such a huge dimension that the topic deserved an explicit accounting in the UN Sustainable Development Goals (SDGs) (Johnston, 2016), with the SDG 3 (target 3.6 - "By 2020, halve the number of global deaths and injuries from road traffic accidents"). Starting from an analysis of the problem on a global scale, involving High-, Mid- and Low-Income countries, we focused our efforts on High-Income Countries (HIC) and, ultimately, on Italy. Italy was expected to be representative of HIC, while providing many advantages for the team, such as the possibility to come in contact with institutional stakeholders. The development of an effective solution is linked to the capability of meeting requirements from institutional stakeholders and road operators. In that sense, the issues faced when dealing with road safety are not related to technologic deficiencies, but to the complex environment (institutions, infrastructure, road operators) in which the solution should be implemented.

Unveiling the strong interconnection between public institutions, road operators and field experts is a challenge in the challenge. Indeed, understanding how innovation develops in the field of drivers' safety was one of the hardest tasks the team faced in the whole project. The solution developed relies on this understanding, and it can be considered both the outcome of the innovation process and the team contribution to partially achieve target 3.6.

THEORETICAL BACKGROUND

Road crash fatalities are a complex global health issue strongly correlated to different factors, such as countries income level and spread of motorization. Mortal accidents on roads are not equally distributed all over the world (Fig.1), where the mortality rate per 100,000 people for different continents is reported. Africa is leading this chart with a value of 26.7 deaths per 100,000 people, three times more than Europe (assessed at 7.8).

[1] In this work, safety is referred to drivers' life. Thus, anything that improves the survival chance of drivers on the road is considered a safety measure.

However, the problem of road crash accidents is not a plague that affects Low-Income Countries (LICs) and Middle-Income Countries (MICs) only. Indeed, it is one of the three leading causes of death in European Countries and it is the primary cause if considering European citizens under 50 years of age. More than 40,000 deaths per year occur on European roads (Commission of the European Communities, 2003), and similar numbers can be found in the United States (Insurance Institute for Highway Safety, 2018). The main causes underlying road crashes deaths can be grouped in two broad classes, namely prevention and post-crash care.

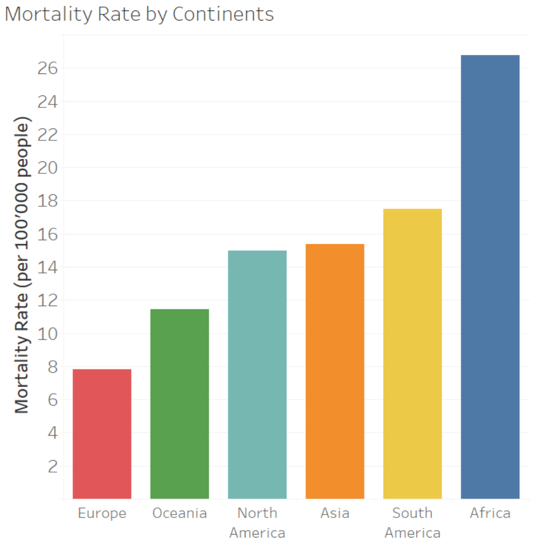

Fig. 1. Mortality Rate (per 100,000 people) distribution according to the continent

Prevention

Accident prevention can be implemented from strict laws and road safety campaigns to more intelligent vehicle systems and road infrastructure researches. Excess speed, missing seatbelt or motorcycle helmet and drunk driving, as well as distraction due to mobile phone usage are the main causes of road accidents in HICs (Istat, 2019). In the last decades, HICs strengthened the control over road law compliance to reduce the number of deaths and hospitalization due to accidents. However, despite global plans such as the Decade of Action for Road Safety 2011–2020, the results show a slow trend in decreasing the road fatalities rate.

Post-crash care

Post-crash care is a complex topic and one of the pillars of road safety strategy (World Health Organization, 2016), but it is often overshadowed by road safety programmes focused on prevention. Post-crash care can involve many different actors and procedures: it starts with the accident detection and it terminates with the correct hospitalization of the victim. The first phase of accident detection and emergency call is sometimes not fast enough. The relevance of this last point is undoubted: every minute saved in this phase can increase by 5% the survival probability in severe crashes (Soro and Wayoro, 2017). The importance of a rapid response in emergency care can be a fundamental factor when fatalities occur in rural areas rather than the urban ones, where the time from accident to pre-hospitalization is longer. A New Zealand research showed that an improved post-crash treatment could have increased the chance of survivability in 11% of the fatal cases examined (Frith, 2018). A Swedish study on fatal injuries reported that among the survivable injury cases analysed, for 5% of them the rescues were not located in time and 12% could have survived with a quicker transportation to the hospital (Frith, 2018). The European Commission has declared that several thousands of lives could be saved by only improving the post-impact response (SafetyNet, 2009).

Beside these relevant data that help in understanding the dimensions of the issue, it is worth to analyse the most successful projects in this field. In doing so, one can identify the common features among these projects and develop an effective solution. Among the most successful solutions developed in LICs, a network of local transportation to speed up pre-hospital care in Kenya was demonstrated to be extremely successful. Such an achievement was made possible by the correct identification of the underlying issue: mortal accidents are associated to major rural roads, and 75% of injuries were transported to hospital by bystanders with an intervention time between 5 minutes and 10 hours (Macharia et al. 2009). Similarly, in Vietnam, motorcycles for emergency care providers successfully replaced common ambulances (World Health Organization 2016). Another effective solution can be found in South Africa, where local community members are trained for prehospital emergency care. Moving to HICs, European Union implemented a procedure based on two-vehicles Rendez-vous to improve pre-hospital efficiency. Two different emergency vehicles are sent to the accident location: an ambulance with a standard crew and a vehicle with an emergency physician, increasing the emergency response flexibility to high-traffic conditions.

The common denominator among these projects is a clear understanding of the socio-economic ecosystem in which the solution should be implemented: healthcare network, infrastructure, institutions and private contribution. Any attempt to transfer a working solution to countries with different socio-economic conditions is doomed to fail (Global status report on road safety, 2018).

METHOD AND DATA

Five main steps related to the innovation process can be identified: definition of the problem, ideation, solution design, validation and prototyping.

Understanding the core of the problem is a crucial, initial step. Reducing road deaths is quite a huge and complex topic. Thus, an extensive literature analysis, followed by an historical data analysis, was performed in this first stage. In doing so, the problem has been quantified and the post-crash care inefficiency was identified as one of the main factors affecting road deaths.

Then, the ideation took place. Our team organized this phase in an iterative process made by research and brainstorming. This approach was highly efficient, allowing a narrowing of the problem and the production of many ideas to tackle it. Alongside, interviews with the Italian healthcare system (Croce Rossa and Croce Verde) helped the team to get a view on the real situation in Italy.

Once the most suitable ideas were identified, we started the design of possible real solutions. At this stage we needed to get external feedbacks in order to start the non-linear iteration processes. One of the possible ways to obtain this information was by sending surveys to all our network of people and get the feedback from the final user of our solution, which is the driver. Conversely, we decided not to take in consideration this hypothesis because we guessed that the field we were working on was more institutional rather than market-driven. Thus, our decision was to involve in the design phase of the solution only stakeholders that could be considered as experts of the field, such as road operators, health care organizations and national institutions.

In light of this considerations, we managed to interview the two most important road operators in Italy, namely ASPI and ANAS; they helped us in understanding how the process of accident detection works and the timescale involved. They also gave us their vision of the next 10 years for the Italian road infrastructure development. Another fundamental achievement was to interview the Italian Ministry of Transport, which provided us a comprehensive view on the road infrastructure, legislation and future projects.

Once the solution was translated from an idea to a set of possible practical realizations, we finally decided to include in the process both possible customers and the final users (drivers) to perform a market validation. This phase was crucial because we got to know if the idea we came up with would have a market appeal and financial stability.

Since the goal of I4C is to develop real solutions to real problems, the last step was prototyping. Even though it may look the hardest part of the innovation process, once the previous steps are correctly performed the prototyping is quite straightforward. Only few technical details were updated in this last step.

RESULTS

One of the first relevant output obtained from the interviews was related to the problem landscape definition. In particular, it was found out that the limitations in this field are not given by technological aspects, but mainly from institutional and infrastructural constraints. This step was ultimately important to focus the effort of the project in the right direction; the technology was already out there, so we needed to follow a market pull approach rather than a technology push one.

In light of this, the most important feedback was given to us by the Italian Ministry of Transport (MIT). As a matter of facts, the Ministry revealed us that governments all over the world are pushing towards safer and connected roads. In particular, in Europe there are already laws at national and international level that pave the way to the so-called Smart Roads, with strict requirements to be met in the next ten years. With these rules, European countries must implement several features on their roads to improve drivers experience and safety, such as continuous monitoring of traffic, automatic reporting of accidents or warning messages for dangerous weather conditions.

This report of the Ministry not only confirmed that we were working on a relevant topic, but also that private motorway concessionaires are obliged to make a change. This fact was extremely important in the development of the project since we envisaged this obligation as a market opportunity and a chance to innovate. In fact, when dealing with road safety regulations, it is difficult to bring real innovation; motorway concessionaires tend to be cautious by thinking primarily to meet the criteria determined by law, suffocating in this way out-of-the-box ideas and, ultimately, innovation itself. In this case, we exploit the very same limitation of this mindset (which is law-driven) to introduce elements of innovation.

Once defined the market and the framework of the project, we developed our solution through a series of interviews with the main motorway concessionaires present in Italy, namely ASPI and ANAS. We found out that the detection of road accidents on highways still relies on human control through cameras located in strategic point of the roads. According to them, this system is strongly reliable and allows the detection of an accident within five minutes from the crash. While it seemed standard and efficient for the interviewed concessionaires, our team arose a question: what if we shorten the accident detection time down to zero? From this challenge we developed EyeWay.

EyeWay is an easy-to-install box exploiting already existing technologies able to instantaneously detect an accident and make the emergency call. This solution is designed by taking inspiration from the most developed sensor in the world: the human being. As a matter of fact, EyeWay is able to “see”, “feel” and “hear” the accident as if a real person is standing by the roadside checking that everything is fine and calling for help in case of troubles.

From a technological point of view, this system exploits three different sensors whose outputs are elaborated to assess whether an accident has happened or not with an extraordinary reliability. In particular, the device is composed of an accelerometer, a TOF (Time Of Flight) radar and a microphone. The accelerometer is able to "feel" the accident whenever a vehicle hits the guardrail, whose detection is made through the reading of the variation of the acceleration of the sensor. The radar assesses the traffic conditions, being able to determine if traffic is flowing or not. Through proprietary machine learning algorithms, we are able to distinguish normal traffic jams to a car involved in an accident. The last sensor, the microphone, is instead able to "hear" the road and differentiate the standard traffic noise from the one produced by an accident. Even in this case, through machine learning algorithms it will be possible to associate the pattern of the noise to a typical situation (Foggia, 2016). Each of those sensors, taken separately, would not be able to accomplish the final goal of detection with high reliability; the novelty of this system is in fact given by the integration of their output signals to assess the presence of an accident, with a triple-check mechanism that will reduce dramatically false positives/negatives.

The implications of such a solution would be dramatic in terms of saved lives. In fact, according to the National Highway Traffic Safety Administration (NHTSA), the emergency call on highways is made on the average 4 to 5 minutes after the accident (Meng and Weng, 2013), confirming the data collected from the interviewed Italian motorway concessionaires, too. With the system proposed in this paper, the same call would have been made within tens of seconds, increasing in some cases the chance of survivability of about 30%.

DISCUSSION AND CONCLUSIONS

In this paper, the innovation process in the field of road safety was analysed, and a possible solution to tackle road deaths was presented.

The geographical aspect was considered in order to evaluate the spread of the problem. It turned out that the there is a strong correlation between road accidents mortality rate and the income level of a single country. For practical reasons, the team focused on HICs, specifically on Italy.

High prevention standards are implemented in HICs, but there is room for significant improvements in post-crash care. The role of drivers and healthcare network was found to be very limited in the innovation of safety systems, even though they are the main beneficiary of such systems. Instead, public institutions and road operators dominate the scene in this field. The main driver for innovation has been identified with MIT. Thus, an effective strategy to implement solutions in Italy starts from the knowledge of MIT planning, such as the Smart Roads decree. The crucial information retrieved from the Smart Roads decree allowed for the development of EyeWay. Without the optical fibre network on highways foreseen by Smart Roads decree, the whole solution would have been meaningless. Further investigation on the relation between public institutions and road operators in EU countries could assess the validity of Italy as representative of HICs. The authors are confident that this is the case, because the Smart Roads decree integrates EU recommendation for improving road safety – thus similar standards should be adopted by EU countries. This situation highlights a possible criticality for innovation in road safety: since public institutions are the driver, the pace at which innovation can take place is strictly related to the decisional process of such institutions. For countries as Italy, in which this process is extremely slow, innovation may struggle. This explains also why in LICs and MICs such a huge gap in road safety exists, if compared to HICs. Public institutions must face more pressing issues, such as hunger or water and electricity availability. Road operators are absent, or, if exists, do not have any economic advantage in improving safety measures. Thus, prevention and post-crash care progress very slowly.

The developed solution, EyeWay, supports post-crash care by exploiting already existing and low-cost technologies. The real challenge is ensuring high reliability, easy installation and maintenance and, obviously, economic feasibility. Again, these are shared requirements among HICs, but the way in which they can be satisfied may differ, depending on road infrastructure, laws and institutions' will. Therefore, the spread of an effective solution outside national borders may result difficult, even among countries with similar socio-economic conditions.

Future works may include EyeWay test in laboratory under relevant conditions, simulating highway traffic and crashes, to assess the system reliability. Also, a small network of sensors shall be set up to simulate the real architecture of EyeWay network on a smart road.

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REFERENCES

Commission of the European Communities (CEC, 2003) European road safety action programme: Halving the number of road accident victims in the European Union by 2010: A shared responsibility Communication from the Commission.

Foggia, P., et al., 2016, Audio Surveillance of Roads. A System for Detecting Anomalous Sounds, IEEE Transaction on Intelligent Transportation Systems, 17(1): pp. 279-288.

Frith, WJ, L Early, J Thomas, R Jackett & K O'Donnell (2018), Post-impact care: How can New Zealand address the fifth pillar of road safety?, NZ Transport Agency research report 645.

Global status report on road safety 2018. Geneva: World Health Organization; 2018. Licence: CC BYNC-SA 3.0 IGO

Johnston, R. B., 2016, Transforming our world: the 2030 agenda for sustainable development, Report A/RES/70/1, United Nations. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

Insurance Institute for Highway Safety, Fatality Facts, 2018. https://www.iihs.org/topics/fatality-statistics

Istat, 2019, Incidenti stradali, 2018 report update. https://www.istat.it/it/files//2019/07/Incidenti_stradali_2018_aggiornamento_Ottobre2019.pdf

Macharia, W.M., Njeru, E.K., Muli-Musiime, F. & Nantulya V., 2009, Severe Road Traffic Injuries in Kenya, Quality of Care and Access, African Health Sciences, 9(2): pp. 118–24. https://pubmed.ncbi.nlm.nih.gov/19652745

Meng, Q. & Weng, J., 2013, Uncertainty Analysis of Accident Notification Time and Emergency Medical Service Response Time in Work Zone Traffic Accidents, Traffic Injury Prevention, 14(2): pp. 150-158. https://doi.org/10.1080/15389588.2012.708886

Plainis, S, Murray, I.J, & Pallikaris, I.G., 2006, Road Traffic Casualties: Understanding the Night-Time Death Toll, Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention 12 (2): pp. 125–28. https://doi.org/10.1136/ip.2005.011056

SafetyNet, 2009, Post Impact Care.

Soro, W. & Wayoro, D., 2017, A Bayesian analysis of the impact of post-crash care on road mortality in Sub-Saharan African countries, IATSS Research, 41(3): pp. 140-146. https://doi.org/10.1016/j.iatssr.2017.01.001

World Health Organization (WHO), 2016, Post-Crash Response.